A financial analysis of agricultural production systems in the Warm Bokkeveld

by

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Declaration

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Summary

The South African deciduous fruit industry is a large source of trade income and a major employer of the country's labour force. The majority of the industry is situated in the Western Cape, a province that has a typical Mediterranean climate. The Warm- and Koue Bokkeveld are the two regions contributing the largest percentage of pome and stone fruit production in the Western Cape. The Warm Bokkeveld accumulates less cold units throughout the winter period and as a result has lower fruit quality and yields in comparison with the Koue Bokkeveld. The above described phenomenon is known as delayed foliation.

Low-chill apple cultivars were bred to overcome the issue of delayed foliation. These apples can be cultivated in areas that accumulate less cold units during winter periods. Currently they are only produced in the Mookgophong area in Limpopo. The orchards are in their third year of production, but the results so far are extremely promising. The Warm Bokkeveld was identified as a region where producers could stand to greatly increase their profitability by cultivating low-chill apples.

Thus far the financial implications of incorporating low-chill apples into a farming system are unknown. Therefore, this study sets out to determine the financial implications of cultivating low-chill apples in the Warm Bokkeveld.

Farms are extremely complex systems that consist of multiple interrelated components. To accurately model a farming system, a systems approach is required. A whole-farm budgeting model was developed to assess the financial performance of various farming systems in the Warm Bokkeveld. To accurately model farming systems in the Warm Bokkeveld, a typical farm that represents the producers in a homogenous area was established. The typical farm and budgeting model were constructed through personal communication with a multi-disciplinary group of experts.

Two farming systems were constructed and evaluated. The first farming system consisted of a typical farm that represents current producers in the Warm Bokkeveld. The second farming system was the same typical farm, but low-chill apples had been incorporated into the farming system. The Internal Rate of Return (IRR) and Net Present Value (NPV) were used to compare the profitability of the two farming systems. Based on the profitability criteria, a farming system that includes low-chill apples is considerably more profitable than the standard farming system in the Warm Bokkeveld. The higher profitability of farming system two is directly attributed to the performance of low-chill apples.

To account for possible variations in the performance of low-chill apples, a sensitivity analysis was conducted where the price and yield levels of low-chill apples were altered, and the respective IRRs were calculated. The result of the analysis indicate that the yield would have to drop with 50% and the price level with more than 50%, for farming system one to be more profitable. Hence, the cultivation of low-chill apples can greatly contribute to the profitability of producers in the Warm Bokkeveld.

Opsomming

Die Suid-Afrikaanse sagtevrugte industrie is ŉ belangrike bron van handel inkomste en skep werk vir die land se werksmag. Die industrie is geografies hoofsaaklik in die Wes-Kaap geleë, met ŉ tipiese Mediterreense klimaat. Die Warm- en Koue Bokkeveld is twee van die belangrikste streke wat betref steen- en kern-vrug produksie. In die Wes-Kaap. Die Warm Bokkeveld se geakkumuleerde koue-eenhede deur die winter is laer as die van die Koue-Bokkeveld met gepaardgaande laer vrugkwaliteit. Die verskynsel staan bekend as vertraagde bot.

Laer kouebehoefte appel is geteel om die voorkoms van vertraagde bot te oorkom. Die appels kan dus in areas verbou word wat minder koue-eenhede deur die winter akkumuleer. Tans word die appels kommersieel slegs in die Mookgophong area in Limpopo verbou. Die boorde is tans in die derde jaar na plant, maar vroeë resultate lyk belowend. Die Warm Bokkeveld is geïdentifiseer as ŉ streek waar produsente moontlik winsgewendheid kan verbeter deur laer kouebehoefte appels aan te plant. Sover is die finansiële implikasie van die insluiting van laer-kouebehoefte appels onbekend. Die studie fokus dus op bepaling van die finansiële implikasies van die verbouing van laer kouebehoefte appels in die Warm-Bokkeveld.

Boerderye is geweldig komplekse stelsels bestaande uit veelvuldige interverwante komponente. Die stelsels benadering is aangewend om die Boerdery stelsel akkuraat te modelleer. ŉ Geheelplaas, begrotingsmodel is ontwikkel om die finansiële prestasie van verskillende produksiestelsels in die Warm Bokkeveld te evalueer. ŉ Tipiese plaas benadering, wat die produsente in die relatiewe homogene produksie area van die Warm Bokkeveld verteenwoording, is gebruik. Die tipiese plaas identifisering en model ontwikkeling is in samewerking met ŉ multidissiplinêre groep kundiges gedoen.

Twee boerderystelsels is ontwikkel en vergelyk. Die eerste stelsel beskryf ŉ tipiese plaas soos wat tans in die Warm Bokkeveld bedryf word. Die tweede stelsel simuleer die insluiting van laer kouebehoefte appels in die produksiestelsel. Die interne opbrengskoers van kapitaal investering (IOK) en die netto huidige waarde (NHW) is gebruik om die finansiële uitkoms te meet. Gebaseer op die winsgewendheid maatstawwe is die stelsel wat laer kouebehoefte appels insluit, na verwagting meer winsgewend as die huidige stelsel vir die Warm Bokkeveld. Die hoër winsgewendheid is direk die gevolg van die laer kouebehoefte appels se insluiting.

Om voorsiening te maak vir variasie in die prestasie van die laer kouebehoefte appels is ŉ sensitiwiteit analise gedoen wat verskillende prys en opbrengs vlakke se impak op winsgewendheid toets aan die effek op die IOK. Die resultate dui aan die opbrengs met meer as 50% kan verlaag voordat die huidige produksie stelsel meer winsgewend sal bly. Dit wil dus voorkom of die insluiting van laer-kouebehoefte appels kan bydra tot meer winsgewende produksiestelsels in die Warm Bokkeveld.

This thesis is dedicated to my parents, for providing me the opportunity to do my Master's degree.

Biographical sketch

Michael de la Porte was born in Centurion, Pretoria on 17 October 1994. He grew up in Machadodorp, Mpumalanga and attended Chazon Tekna Pre-primary in 2000 and Chazon Tekna Primary school in 2001. After completing primary school his family relocated to Paarl in the Western Cape where he attended Paarl Boy's High School in 2008. In 2013 he started his BSc-degree in Agricultural Economics at the University of Stellenbosch. His passion for the agricultural industry led to his enrollment for an MScAgric degree in 2017.

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- My family for their endless love and support in my life.
- Melandré Schoeman for her motivation, love and support throughout the study.
- God for blessing me with the opportunity, strength and love to finish this study.

Preface

This thesis is presented as a compilation of 6 chapters.

Table of Contents

List of Annexures

ACRONYMS AND ABBREVIATIONS

ARC - Agricultural Research Council

APSIM - Agricultural Production Systems Simulator

APSRU - Australia Production Systems Research Unit

CA storage - Controlled atmosphere storage

CFG - Ceres Fruit Growers

DPCU - Daily positive chill units

DSSs - Decision Support Systems

GDP - Gross domestic product

IDSS – Integrated Decision Support System

IRR - Internal Rate of Return

NPV - Net Present Value

NUANCES-FARMSIM - Farm simulator within Nutrient Use in Animal and Cropping systems: Efficiencies and Scales

SERF - Stochastic efficiency with respect to a function

Chapter 1: Introduction

1.1 Introduction and background

South Africa is a developing country where agriculture still plays a key role in the continued development of the economy. Agriculture constitutes around 2,6% of the country's gross domestic product (GDP) (DAFF,2018). However, it is still an important sector with many forward linkages and employs around 5,47% of the South African workforce (World Bank, 2018). Considering South Africa's high unemployment rate of 27,3%, this further emphasizes the importance of the agricultural industry (World Bank, 2018). Agricultural commodities are an important earner of trade income. South Africa is known for diverse ecological and climatic regions ranging from semi-arid to Mediterranean climates (Wand *et al.,* 2007). The climatic regions throughout South Africa have resulted in the country having a diverse agricultural industry. This includes, amongst others, the following: deciduous fruit, sub-tropical fruit, intensive and extensive livestock farming systems, cereals, dairy, oil crops, poultry and wine.

South Africa has one of the largest deciduous fruit industries in the Southern Hemisphere (Theron, 2012). The industry contributes over R 12 000 000 000 per annum to the total GDP, and the industry is an important source of foreign earnings as 44% of deciduous fruit is exported (Hortgro, 2017). The majority of South Africa's deciduous fruit production is located in the Western Cape Province (Hortgro, 2017). The Western Cape has a typical Mediterranean climate which is suitable for the production of a wide-range of deciduous fruit. Certain types of deciduous fruits can only be produced within specific regions that accumulate enough cold units throughout the winter. This includes pome fruit (apples and pears) and stone fruit (peaches and nectarines). The biggest percentage of pome and stone fruit production occurs within the Ceres area in the Western Cape (Hortgro, 2017). The Ceres area is divided into two distinct regions namely, the 'Warm Bokkeveld' and the higher altitude areas including the 'Koue Bokkeveld'; Bo-Swaarmoed and the Witzenberg valley. The Warm Bokkeveld region is expressed in Annexure A.

The Warm and Koue Bokkeveld have similar climate conditions; however, the Koue Bokkeveld experiences a higher amount of cold units during the winter period (Wand *et al.,* 2007). The higher amount of cold units makes the Koue Bokkeveld a more suitable region for cultivating pome and stone fruit. This is true, especially when it comes to the production of apples. The Koue Bokkeveld is therefore considered a more profitable region where producers cultivate better quality fruit with higher yields. Due to the lower cold units in the Warm Bokkeveld, the quality of the fruit and the yields harvested are lower than the Koue Bokkeveld. This is due to a phenomenon called delayed foliation that affects plant growth and it is as a result of a tree not accumulating enough cold units (Allderman *et al.,* 2011).

Low-chill apples were bred to overcome the problem of delayed foliation. These apple cultivars do not require the high amount of cold units that standard cultivars require. This could potentially expand the regions where apples can be cultivated. Studies have been done in various countries that focus on the farming practices involved in the cultivation of low-chill apples (Castro *et al.,* 2016; Melke *et al.,* 2016). In 1995, the Agricultural Research Council (ARC) started a breeding program for low-chill apple cultivars in the Western Cape (Schmidt *et al.,*1999). As previously mentioned, the Western Cape is the largest producer of apples in South Africa but some regions are not cold enough and experience delayed foliation. Regions such as the Warm Bokkeveld could potentially be considered for the cultivation of low-chill apples. Currently Limpopo is the only province that has producers farming low-chill apples on a commercial scale (Von Mollendorff, Personal Communication, 2018). The orchards are currently in the first few years of production and the actual potential of the apples will only be confirmed in the coming years.

The problem concerning low-chill apples is that there are no studies conducted to determine their financial feasibility. How do they differ from standard apple cultivars? Why has commercial production only taken place in Limpopo? Questions asked according to experts are; what are the predictions on these apple's performances? What are the financial implications of including low-chill apples in the Warm Bokkeveld? And lastly, what is the financial feasibility of low-chill apples in the Warm Bokkeveld?

1.2 Research objectives of this study

The previous section highlighted the problem that producer's face in areas that do not acquire sufficient cold units for deciduous fruit production. Low-chill apples have been identified as a crop that can overcome this problem in the Warm Bokkeveld.

The main purpose of the study is therefore to determine the financial feasibility of low-chill apples in the Warm Bokkeveld. The objectives of the research are:

- To assess the current performance of farming systems in the Warm Bokkeveld.
- To assess the performance of low-chill apples in Limpopo.
- To illustrate the financial performance of incorporating low-chill apples into farming systems in the Warm Bokkeveld.
- To compare the profitability of various farming systems in the Warm Bokkeveld.

1.3 Proposed method

To fully comprehend how low-chill apples can be incorporated into a farming system, a literature review will be conducted to study how previous researchers attempted a similar task. The Warm Bokkeveld will also be studied to determine the economic importance of deciduous fruit production in the region.

Farming systems are extremely complex with interrelated components. Therefore, a systems approach is used to integrate specialized knowledge to bridge the gap between different fields. The holistic view of a systems approach views the farming system as a whole and does not isolate various components. This allows the user to view the impact of a change in one component on the entire system.

The purpose of the study is to simulate an alteration on a farming system in the Warm Bokkeveld. To do this, a whole-farm budgeting model is created so that the financial implications of incorporating low-chill apples into a farm are determined. The typical farm is constructed with the input of various producers and agricultural economists in the Warm Bokkeveld. This farm represents a group of farmers in a homogenous area that conduct similar farming activities.

To assess the financial feasibility of low-chill apples in the Warm Bokkeveld, two farming systems (production systems) of the typical farm are modelled. The first farming system assesses the current financial performance of a typical farm in the Warm Bokkeveld. The second farming system determines the financial performance of a typical farm that includes low-chill apples in its crop distribution. The profitability of the two farming systems are then compared using the Internal Rate of Return (IRR) and Net Present Value (NPV) of each farming system.

A wide range of experts are used to ensure the input data in the study is valid. The data is used to build the typical farm and the whole-farm budgeting model. The data includes prices, costs, crop distributions, farming inventories etc. The experts include agricultural economists, pome fruit technicians and producers.

1.4 Outline of the study

Chapter two is a review of the literature used for the study. The purpose for the development of low-chill apples is discussed in depth, as well as the potential benefits and challenges of cultivating these apples. The Warm Bokkeveld is introduced as an area where the cultivation of low-chill apples is possible. Farming systems are discussed in depth and the complexity of these systems is emphasized. To model a complex farming system, it was determined that a systems approach would be required. For the study a whole-farm budgeting model is identified as the means to simulate changes to the farming system. To conduct a whole-farm budgeting model, a typical farm is created to assess the impact of the farming system alterations on the whole farm's profitability.

Chapter three explains the process of developing the whole-farm budgeting model. The economic importance of the Warm Bokkeveld's deciduous fruit industry was discussed. The assumptions and parameters of the typical farm were discussed. The typical farm was validated through discussions with Ceres Fruit Growers (CFG) and multiple producers in the Warm Bokkeveld. To ensure accurate assumptions were made for yield and price levels of these apples, discussions were held with farmers and pome fruit technicians currently involved in the production process. The interrelatedness of the components in a budgeting model is explained by way of an example. The example proposes an alteration in the input data (yield assumption), and the resulting effect that this alteration has on the entire model.

Chapter four discusses the application and results of the whole-farm multi-period budgeting model. The results of the two farming systems are discussed in depth. The capital requirement and profitability components are explained in more detail. The capital requirement consists of land, fixed improvements, machinery, vehicles and implements, and this component has a major influence on the profitability component. The results of the profitability are discussed, and the two farming systems are compared with each other. The assumptions on the performance of low-chill apples were validated through expert discussions. However, there is a lack of information regarding the actual performance of these apple cultivars. Therefore, a sensitivity analysis is conducted to measure the impact of altering these assumptions on the overall profitability of farming system two. This is done by running scenarios where the price and yield of low chill apples are altered and the resulting impact on the profitability is measured.

Chapter five includes a conclusion for the entire study. A detailed summary is given that highlights the major research findings throughout the study. Recommendations for possible future studies are also made.

Chapter 2: Literature review

2.1 Introduction

The chapter focuses on research that has been conducted by various stakeholders on various topics. The research that will be studied and discussed in this chapter will provide an in-depth knowledge of topics that will contribute to solving the research question for this study. It is important to know what methods other researchers have used to answer similar research questions. This provides a good basis on which method will be most suitable for the current study.

The chapter includes a summary of literature that was studied to answer the research question of this study. It was determined that a systems approach would be taken to solve this question. Therefore, the first topic focuses on systems thinking. The following topic deals with agricultural systems and the use of modelling to help make on-farm decisions that result in a more efficient and sustainable farming practice; it also looks at significant events which contributed to the development of agricultural systems models. A significant amount of research was conducted on various research tools that could be used to address the research question. These tools consisted mainly of Decision Support Systems (DSSs) which are software applications that can be applied to simulate the effect of on-farm decisions (irrigation, fertiliser application, etc.), as well as uncontrolled variables (droughts, storms, etc.).

Producers face a high degree of risk and uncertainty when making important decisions such as an investment in new machinery or establishing alternative enterprises. Scientists have developed models which can account for certain risks and uncertainties to help producers in the decision-making process. With regards to farming, climate change is considered one of the largest risk factors for producers. This was observed with the drought the Western Cape has experienced since 2013 which affected the profitability of many producers in the province. Producers should take this into account and ensure that they are conducting sustainable farming practices. The final part of this chapter concentrates on low-chill apples. This section discusses the purpose for developing these cultivars and the findings of researchers in various countries. Identifying the potential benefits and challenges concerning the production of these apples is also tremendously important as it can indicate the potential scope for these apples. Finally, the areas where these apples can be produced are identified.

2.2 Farm Systems (Agricultural systems)

There are various forms of agricultural systems and, in this chapter, they will be identified and described, and finally a suitable model will be chosen to ultimately answer the research question of this study. Jones *et al*. (2016: 241) defines agricultural systems as, “a collection of components that has as its overall purpose the production of crops and raising livestock to produce food, fibre, and energy from the Earth’s natural resources. Such systems may also cause undesired effects on the environment.” Agricultural systems science therefore studies the behaviour of these multipart agricultural systems. These studies can be extremely useful for collecting data and determining the behaviour of agricultural systems under certain conditions but there are many cases where it cannot be used. To be able to use this science, it is important to include models that consider the link between production, natural resources and human aspects. Farming systems are inherently complex, owing to the interrelatedness of components (Hoffmann, 2010). Therefore, small changes to certain variables can have an enormous effect on the entire system. For this reason it is important to view the entire system as a whole and the concept of the systems approach will be discussed more in depth in the next section.

These agricultural system models help us to understand and predict the performance of agricultural systems under diverse circumstances. For these models to be accurate, data is required to run, evaluate and develop these models as well as other supporting tools that are required to accurately communicate the results of these systems to help with decision-making. Models can assist producers and policy makers by identifying options that can improve the sustainable use of land; as long as all of the information regarding climate, soil, management practices, and socioeconomic issues, etc. are available. The use of agricultural system models dates to the 1950s and since then models are continuously being improved and adapted to generate accurate results for specific circumstances. The most important aspect of these systems is data; inadequate data will reduce the credibility that these models have for the users. However, it is important to consider the history of the agricultural systems and use the lessons learnt to ensure the production of new and more efficient models. C.T. de Wit, from Wageningen University was a key figure in the use of agricultural systems modelling; he believed that the combination of physical and biophysical principles is required for these models (Jones *et al.,* 2016). Figure 2.1 indicates the timeline of significant events that influenced the development of agricultural systems models.

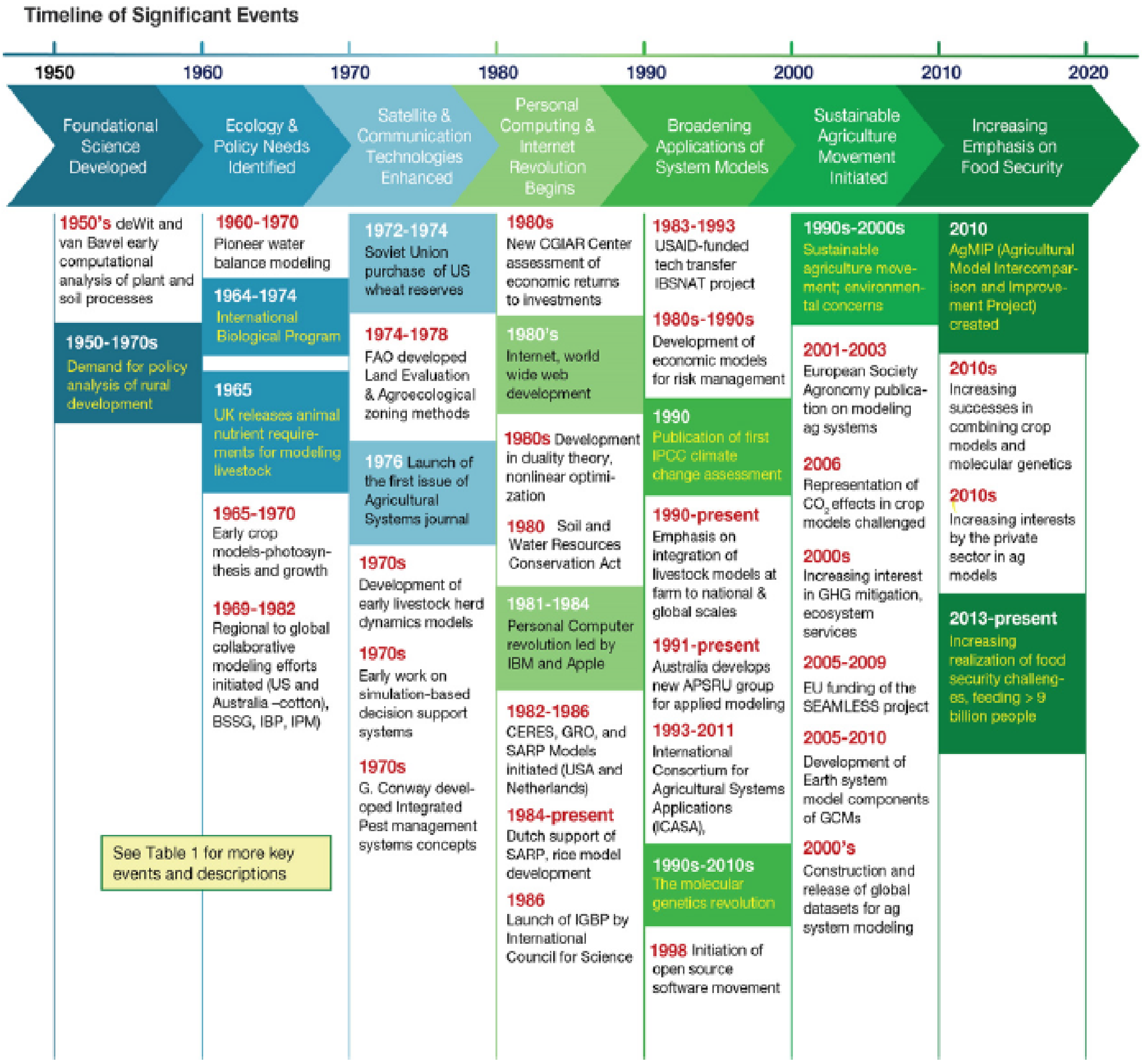

Figure 2.1: Key events leading to development of Agricultural Systems Models
Source: Jones et al.*, 2016*

According to Jones *et al*. (2016) there are three key characteristics found in the development of agricultural system models, namely: purposes for model development, approaches for modelling agricultural systems, and spatial and temporal scales of agricultural system models. The two main purposes for model development are to increase scientific understanding and to gain policy support. However, for this study the purpose is to develop a model to analyse the profitability of various farming systems. The modelling of farming systems enables the researcher to determine which farming system has the highest profitability.

Models used for increasing scientific knowledge have a more mechanistic nature and are considered explanatory (Jones *et al.,* 2016). Models increase our understanding by addressing research questions that target processes and the responses of these processes. An example of this would be measuring the nutrient uptake of livestock at various stages in their life cycle. These explanatory models describe processes at a fine time scale (e.g. hourly nutrient supplies in livestock) and usually include a list of parameters where some are unknown or include high uncertainties. The study involves exploratory research as there is currently no data available on the profitability of a farming system that incorporates low-chill apples into its crop distribution. A model will be constructed to determine the expected profitability of a farming system which includes low-chill apples. To overcome these uncertainties a set of assumptions have to be made to build the model and conduct the study. Therefore, the underlying problem is that with uncertainties present in assumptions and hypotheses, the outputs achieved by these models may be incorrect or uncertain.

Functional models incorporate the use of empirical functions to calculate multifaceted processes, such as the ability of a plant's leaf area to absorb heat energy. These models require field data that can be used to produce robust analysis results. It is found that for the same types of livestock, crops and farming systems there are multiple models that have been developed. This is mainly due to the fact that different research groups concentrate on different relationships between the factors in the farming system. Owing to this, agricultural system models have various levels of complexity, accurateness and information requirements. This was highlighted by the study of Asseng *et al*. (2013) where they discovered that various models simulating wheat yields under climate change generated various results, as different crop models include different parameters and have different structures. As previously mentioned, the second purpose for model development is to help support policies and decisions by providing relevant information regarding these policies/decisions. For this to be possible, models have to be able to explain causality of agricultural systems and how they react to external environmental factors, and the decisions or policies that could be implemented. The information that is provided is useful for society with regards to decision making and it is used to support a specific policy that could be implemented. The users of this model benefit from the information as they can make better decisions if they are aware of how agricultural systems would respond should these decisions or policies are implemented.

The second characteristic of model development concentrates on the approaches for modelling agricultural systems. One approach consists of statistical models that make use of historical data on various factors to make predictions such as crop yields or commodity prices, etc. (Jones *et al.,* 2016). Some of the very first large-scale agricultural models made use of weather and yield data for crops in a specific region. This made it possible to predict the yields producers could harvest in the years to come. A major setback with these models is that they do not account for the climate change that takes place every year and it is also very region specific, placing constraints on farmers that are not within these regions. Systems Dynamics Modelling is another widely used approach to agricultural systems modelling. These models do in fact account for the changes in external factors such as climate and management practices, and it can be used for various farming systems. These models can simulate responses over specific time periods and include any variables required giving it the ability to compare the result of alternative decisions on the entire farm. If the model is accurate the responses that it provides can be compared to what would happen in the real system. Hence, it is important to compare the model with the real system to determine the accurateness of the model and the level of uncertainty that exists.

Agricultural systems modelling can be used across a broad spectrum of stakeholders, from farmers to government policy makers. Depending on the stakeholder, the models are used for different purposes. Producers use these models to improve decision making when there is a level of uncertainty, and policy makers use them to determine the impact of policies on various aspects from production levels to environmental factors (Peart & Curry, 1998). These models make use of a significant amount of data to predict what would happen in the real world. The usefulness of the models depends heavily on the data that is used in the development process. To ensure the continuous development and improvement of these models, uncertainty levels should be better communicated to the users. It is important that these models are developed with various assumptions on what should be included in the model and how these components interact with each other and how they react to alternative scenarios. Hence the well-known quote from Box & Draper (1987: 424): “All models are wrong, but some are useful.”

There is an increasing amount of literature that is concentrating on the development of new agricultural systems and models that are referred to as “NextGen” agricultural systems. The reason for this is that, because by 2050, it is estimated that the world population will be more than 9 billion people (Béné *et al.*, 2015). The main challenge is to develop a more sustainable and productive agricultural sector that will be able to address this issue of food security on a global scale. The development of these NextGen models is made possible by the increase in data-capturing, computer technology and information technology. To ensure that these models are suitable for the task, it is important to consider the user needs, this will ensure that the data that is retrieved can be used to develop accurate outcomes. However, for this study the focus was not placed on the development of NextGen models.

2.3 Systems Approach

As mentioned in the previous section, the study will follow a systems approach to determine the impact of changing variables on the entire system. Traditionally studies that focused on farm systems would take on a reductionist approach. This form of approach isolates certain segments of a system and studies it separately, hence the link between variables in a system is completely ignored. The reductionist approach therefore does not represent the impact that a change in certain components of a system has on the entire system (Basson, 2017). Therefore, for this study a reductionist approach is not suitable.

Farm systems are large and complex, and a multi-disciplinary approach is required to integrate specialized knowledge and bridge the gap between different fields (Knott, 2015). A systems approach can be used for these complex farm systems. The concept of systems thinking approach has been used for decades, and it is extremely useful with regards to how land should be efficiently managed (Bosch *et al.,* 2007). A systems approach involves the interactions between hard (biophysical) and soft systems (biophysical, family and technology). This way of thinking also recognizes that the system is part of a larger one that can provide information with regards to on-farm decision making. This form of approach is widely accredited because of its holistic view which allows stakeholders to discover new interactions in real world situations (Röling & Jiggins, 1998). To ensure that decision-making is improved it is important to look at the entire system as a whole and not to isolate any parts of the system. This holistic view allows the stakeholder to make better decisions whilst taking risk and uncertainty into account. The continuous innovation of computer software programs allows for the further development of systems approaches. This innovation enables the user to apply a systems approach to increasingly complex farm systems.

For this study it is important to include the main components influencing profitability. This includes production region, crop yields, input costs, and product prices, etc.; taking all of the components into account will allow for a comparison between the different farm systems as described earlier.

2.3.1 Risk and Uncertainty

There are many risks in the farming business and a producer makes decisions with a lot of uncertainties about various events that could negatively impact his profitability. Factors such as weather, prices and political instability would have a big impact on the outcome of a farmer's profitability. For this purpose, researchers have taken it upon themselves to study these risks and uncertainties and document their literature to make information more available to producers. This information is of great importance to all stakeholders involved in the farming system and it can be used to minimize the farm's exposure to risk. This literature was used to develop a range of models that help farmers in making decisions whilst taking risks and uncertainties into account. Farmers use these models to better respond to variations in climate and prices to ensure profitability (Pannel, *et al.* 2000). Achieving this objective would mean that the farmer must make the right decision when it comes to big investments such as land and machinery purchases. Therefore, the most crucial aspects of these models are to ensure that producers are making the best decisions possible given as much relevant information as possible.

All producers have different levels of risk which they are willing to take to engage in the production of a certain commodity. Producers must constantly stay innovative to ensure they do not lose their competitive advantage. This requires them to add new enterprises to their whole-farm enterprise or replace existing enterprises that are not as profitable. However, this involves risk and as producers have different levels of risk aversion, it is important to take this into account when evaluating alternative branches. There is a method called stochastic efficiency with respect to a function (SERF). It ranks a set of alternatives with regards to the certainty of the outcome and the level of the producer's risk aversion (Pannel, *et al.* 2000). Hence, this method takes each alternative option and compares it with various other alternatives across the same levels of risk attitudes. This method also does not require extremely complicated computer software to conduct the evaluations; it can be conducted simply by using a spreadsheet. This method is an example of a tool that producers can use to evaluate risky alternatives, to make a decision that can increase the profitability of the farm.

2.4 Modelling

The use of models has already been mentioned in the previous sections. This section will cover the use of models and the various forms of models that are available to conduct research. The most important aspect of models is their ability to give a representation of something that would not otherwise be observable. Models can represent real-life situations after taking various factors into account, this representation can then be used to make well-informed decisions. The more variables the model includes, the more credible it will be.

2.4.1 General models

Hirooka (2010: 412) defines a model as, "…a simplified and idealized mathematical representation of reality based on an ordered set of assumptions and observations." To construct a model, accurate data and information is required and this is achieved from statistical analysis methods. Modelling is considered a powerful research tool as it arranges current knowledge in a given system which enables researchers to identify the gaps in the research that inhibits the understanding of the system. Figure 2.2 gives a representation of the procedure of modelling under a systems approach.

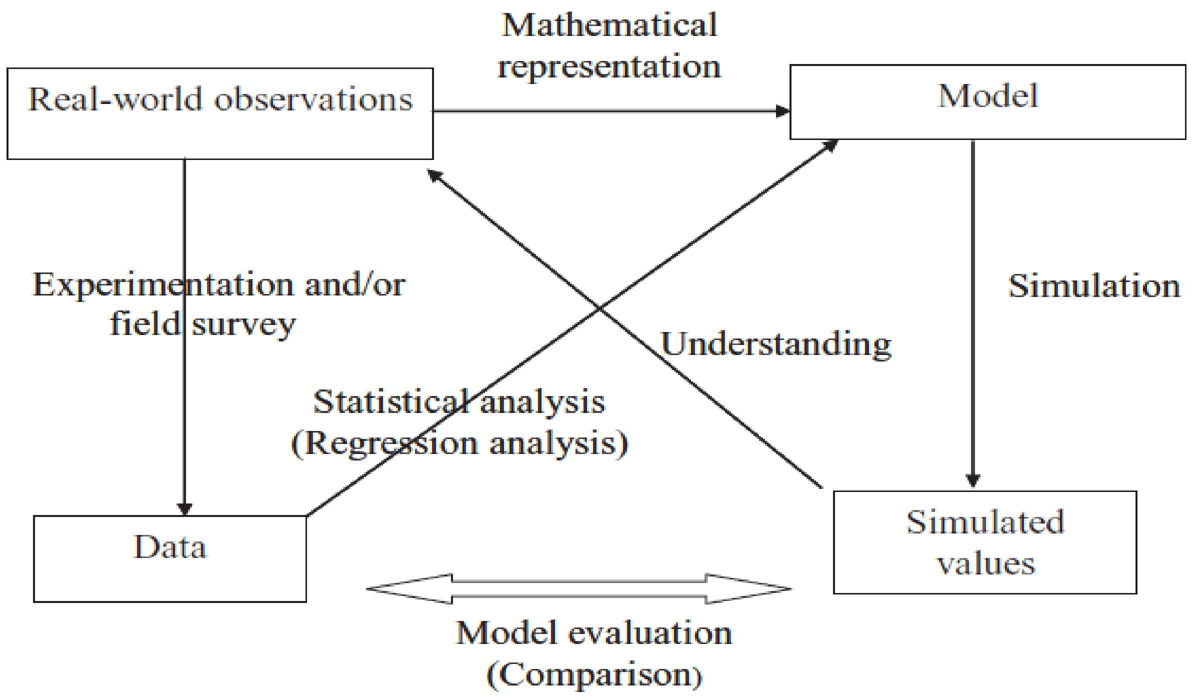

Figure 2.2: Procedure of Modelling
Source: Hirooka, 2012:412

Models are also considered practical and relatively easy to comprehend by farmers (Hoffmann & Kleynhans, 2011). This is extremely important as some farmers are not used to advanced computer software programs.

2.4.2 Simulation models

A farm system model makes it possible to evaluate the outcome of various alterations of input data and assumptions. These evaluations were made possible by the advancement in computer technology (Knott, 2015). The process used to evaluate these alterations is called simulation. A simulation of the model tries to predict what would be observed in the real world should changes be made to the data in the model. The model can then be used to simulate different scenarios which indicate the outcome of changes in the system on the whole system. This enables stakeholders to improve their decision making when it comes to changing input data or assumptions of the model.

Farmers are able to make use of simulation models that can help them to produce more efficiently. These simulations can assist producers in optimizing the farms production levels as well as target specific areas such as irrigation, fertiliser application and soil management. The rest of this section covers models that are currently available to producers.

2.4.2.1 Decision Support Systems

Farmers face many challenges in their enterprises and these challenges can result in the declining profitability of farm enterprises. As a result stakeholders have undergone research to find ways that farmers can make use of scientific knowledge to improve decision making (Jakku & Thorburn, 2010). One of these tools is decision support systems (DSSs). According to Jakku and Thorburn (2010: 675), "Agricultural DSSs are software applications, typically based on computer models that describe various biophysical processes in farming systems and how they respond to different management practices (e.g. irrigation, fertiliser, sowing and harvesting dates) and/or climatic variability (e.g. temperature and rainfall)." DSSs can therefore help farmers to apply inputs more efficiently and/or also determine the impact of climate variation on current crop production levels (Nelson, Holzworth, Hammer & Hayman, 2002).
An example of this DSSs is "Whopper Cropper" which was used in Australia to make information regarding the impact of climate variability on crop yields available to farmers (Nelson *et al.,* 2002). This DSSs contributed to farmers improving crop management by facilitating discussions between farmers and which decisions they should make based on climate forecasts and farm simulations (Nelson *et al.,* 2002). The application was referred to as discussion support software, and producers and other stakeholders had a role in the development of it; it is more demand-driven.

2.4.2.2 Integrated Decision Support Systems

A study done by Clarke *et al*. (2017) focused on the use of an integrated decision support system to address several problems in Ethiopia. In Sub-Saharan Africa the problem of hunger and poverty are still big topics of discussion and emphasis is placed on how this can be reduced. The agriculture sector is normally the country's largest sector and largest employer of labour. Improving this sector can greatly contribute to solving the above-mentioned problems. Developing the agricultural sector requires multiple aspects such as more efficient resource management. The study carried out by Clarke *et al*. (2017) made use of an Integrated Decision Support System (IDSS) for farmers in Ethiopia to determine economic and environmental outcomes should they adopt new technology to improve food production and to improve resource allocation. The results were positive and indicated that more efficient use of fertilizers, irrigation systems and better seeds led to an increase in household income and nutrition, whilst also protecting natural resources (Clarke *et al.,* 2017). The ability and usefulness of an IDSS to predict economic and environmental outcomes for various stakeholders and to add value to existing research has been indicated in this study.

2.4.2.3 Agricultural Production Systems Simulator

The Agricultural Production Systems Simulator (APSIM) is similar to the two above-mentioned research tools. It was developed by the Australia Production Systems Research Unit (APSRU) and it was used to determine economic and ecological consequences of production practices with the inclusion of climate risk (Brisson *et al.,* 2003). The model recognized the need to provide simulations of crop production considering various factors such as soil properties, climate conditions and the use of farm resources. Therefore, this simulator can provide accurate yield information whilst considering the long-run impact of farming practices on soil conditions (erosion, etc.). APSIM has been applied in several different systems such as helping farm decision-making, assessing various climate forecast scenarios, supply chain analysis, etc. (Brisson *et al.,* 2003). These simulations are of great importance to farmers and managers and can ensure that they run their enterprises in a more efficient and sustainable manner.

2.4.2.4 NUANCES-FARMSIM

There was a need for a tool to help smallholder farmers in Sub-Saharan Africa to manage their complex farms. These producers face many challenges such as efficient resource allocation, climatic conditions and socio-economic challenges. The tool should be able to analyse the impact that farm-level decision-making has on the use of resources, and the consequences of these decisions in the short- and long run (Van Wijk *et al.,* 2009). A farm simulator (NUANCES-FARMSIM) within the "Nutrient Use in Animal and Cropping systems: Efficiencies and Scales" framework was developed (Van Wijk *et al*., 2009). This tool integrates crop and livestock components into a model and is used to analyse smallholder farm systems. It follows the Wageningen School of agro-ecological modelling, which focuses on growth and natural resources and efficiency rates to determine production levels (Van de Ven *et al.,* 2003).

The model was applied to a farm in Western Kenya and the sensitivity analysis analysed the entire farm system. Even with the uncertainty included in the model, it was still able to determine important decisions for farmers who concentrate on production. According to the sensitivity analysis the most important factors that influenced the outcomes were: resource allocation, organic matter management and availability of inputs for production (fertiliser and labour specifically) (Van Wijk *et al.,* 2009). These factors highlight the importance of integrating an entire farm's production components into one modelling tool, because in the long run, the production capacity of one enterprise (crops) will influence another enterprise (livestock). From the sensitivity analysis it was deduced that the management of the organic resources was the most crucial. The storage quality of manure, the collection efficiency and the distribution between crops had a major impact on the production levels of the crops in the end.

The NUANCES-FARMSIM is another good example of a model that can help producers with farm-level decisions. The ability of the model to generate outcomes over the long run is also very important, as producers are then able to plan so that they can still produce sustainably in the future. The ability of this model to include the interaction between different farming components ensures that it gives a more realistic representation of the farming system (Van Wijk *et al.,* 2009). Although the simulation was in a specific region in Kenya, it can be adapted to be better suited for other regions as well. These modelling tools can greatly prosper smallholder farmers in developing countries who still strongly rely on agriculture as a source of income and food.

2.4.2.5 Budgeting models

The use of budgeting models is considered to be the least complicated analytical method for improving a farm system (Nuthall, 2011). It is used to evaluate the potential of a farm plan in its physical and financial aspects. Budgeting is also the cheapest method available but it is not always efficient when including multiple systems. However, for larger farms more sophisticated techniques can be applied to ensure that the developed model is efficient. A budgeting model includes the development of the physical aspects of a farm (land, water and other resources) and allocates these to either one or multiple enterprises (livestock, crops, etc.) (Knott, 2015). The model then uses the physical aspects to estimate the incomes and expenses that would be generated should the system be put into use. This enables users to compare alternative enterprises with each other to make decisions based on certain criteria (Knott, 2015).

A well-constructed and feasible budget requires the modeller to have experience and knowledge about the farming system (Nuthall, 2011). For a budget to be feasible the amount of resources supplied should meet the demand (labour, capital, fertiliser, etc.).

Budgeting models can be used to simulate real world situations. However, the simpler models do not account for risk so, depending on the producer, risk can be incorporated from the beginning of the model construction (Nuthall, 2011). The model assumes that certain values such as input-output coefficients, prices and costs, are fixed throughout. This is something that will not be observed in real-life situations. Therefore, modellers account for this by making conservative estimations to ensure that budgets do not overstate the potential of the farming system. This can be done by means of a sensitivity analysis which indicates how profit levels increase or decrease when price or yield levels are changed. This is considered to be the only limitation when it comes to budgeting models. However, by constructing a decision tree or payoff matrix, this limitation can be overcome (Nuthall, 2011).

The type of budget will depend on the purpose of the study. The first budget type is simply for forecasting. It is mainly used to determine future cash surpluses, predict taxation levels, and also to determine what the farmer's entrepreneurial salary could be (Nuthall, 2011). Producers use the budget as a basic guideline for normal day-to-day operations and they are able to track their actual progress and compare it with the forecasted budget. This form of record-keeping shows the producer in which areas of his business he should be more efficient. Forecast budgets can be used for one production year or it can be extended over multiple years.

The next type of budget is a comparative budget. These budgets are extremely useful when it comes to comparing different farming systems (Nuthall, 2011). When the farming system has been chosen it essentially becomes a forecasting budget, as mentioned above. Comparative budgets normally consist of two forms, either partial budgets or comparative development budgets. The former is used when a producer is considering including an enterprise within the entire farming system. It determines the added variable and fixed costs that would occur should the enterprise be implemented, and subtracts them from the expected revenue that would be generated by this enterprise. Hence, the partial budget allows the producer to determine if including the enterprise would be profitable to the entire farming system. Comparative developmental budgets are constructed to compare different farm systems over one or multiple periods. A whole-farm budgeting model is considered to be a more systematic approach. It will be discussed more in depth in the next section.

2.4.3 Whole farm budgeting as simulation model

For this study, whole-farm multi-period budget models will be constructed. This is a form of simulation modelling that is grounded on accounting principles (Hoffmann & Kleynhans, 2011). The whole-farm budgeting model gives a holistic view of the farming system and it can determine the outcome of changes in one component of the farm on the entire system. This is possible due to the development of computer software, which allows the user to model increasingly complex systems. In this case, a spreadsheet program can be used to simulate a whole farm. The spreadsheet program can conduct complex calculations and indicate the interrelationship between various components in the budget model (Pannell, 1996).

An important prerequisite to ensure the model is a good representation of the real world is that the modeller should have an in-depth knowledge of the farm system being modelled. This establishes trust in the results of the model amongst the other stakeholders who are either directly or indirectly involved in constructing the model. The user-friendliness of the model also ensures it can be explained to other users who are not economists or scientists (Hoffmann & Kleynhans, 2011).

The multi-period aspect of a whole-farm budget allows the user to determine the outcome of changes to certain components of the whole-farm system. This is important as farming is a long-term venture and producers need to assess the impact of these changes on the entire farm's profitability.

The following list indicates the most important uses of a whole-farm budget (Kay, Edwards & Duffy, 2012: 195):

- Assessing the expected income, expenses, and profit for a given farm plan.
- Assessing the cash inflows, cash outflows, and liquidity of a given farm plan.
- Comparing the effects of alternative farm plans on profitability, and liquidity, etc.
- Evaluating the effects of intensifying or changing the current farm plan.
- Assessing the need for, and availability of, natural resources and labour.
- Communicating the farm plan to various stakeholders.

The structure of a model can be divided up into three parts, namely: model data inputs, model calculations, and model information outputs. Figure 2.3 gives a detailed description of a basic farm structure. In the first part the structure of the typical farm is described, as well as the inflow variables (product prices and crop yields), outflow variables (variable costs, overhead costs, land and fixed improvements, etc.) and the operational assumptions. The second part of the model focuses on the calculation of enterprise gross margins, overhead costs and asset replacement schedules. The final component of the farm model represents the most important information outputs. This includes a multi-period budget, total gross value of production and total gross margins. In this section the net present value (NPV), internal rate of return (IRR) and cash flow for the various enterprises are calculated (Mugido, Kleynhans & Hoffmann, 2012). These calculations are crucial when it comes to evaluating the potential profitability of an enterprise in the context of the whole farm.

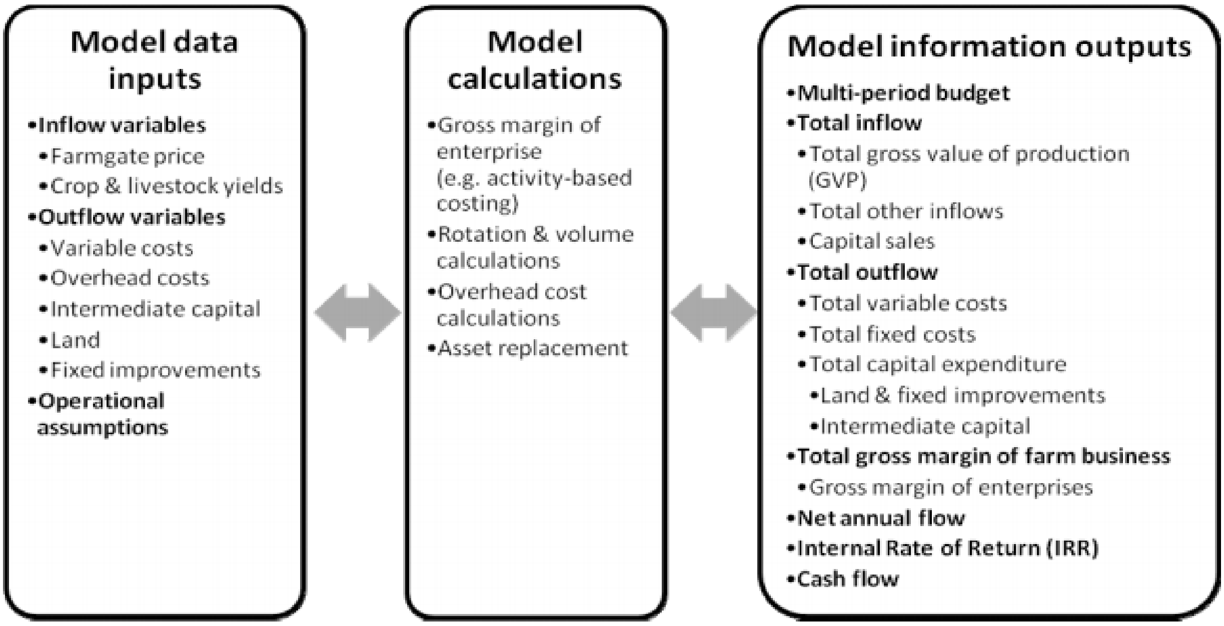

Figure 2.3: Basic farm model structure
Source: Von Doderer, 2009:31

2.4.4 Typical farms

In order to conduct an accurate whole-farm budgeting model it is extremely important to focus on the region where the budget is being conducted. This is because various regions have a different set of challenges that producers have to deal with. Challenges refer to everything from climatic conditions to the availability of natural resources. These challenges have an influence on the way that farm systems are set up in that specific region. Hence, to conduct a whole-farm budget it is first necessary to establish a typical farm in the region being studied.

The concept of typical farm theory dates back to the 1920s when it was used to conduct agricultural economic research (Feuz & Skold, 1992. A model farm was established after taking a number of farms in a given geographical area into account. This typical farm represented a group of farmers who were engaged in the same type of farming activities in the same region (Elliot, 1928). It is important to note that this farm does not represent the average farm, it is considered to be the mode of farms or the one which appears most frequently. The typical farm concept ensures that better recommendations can be made to producers in the region (Elliot, 1928). It was found that constructing a synthetic farm is more efficient than using one specific farm in a region. The most important issues when constructing a typical farm model are whether or not the typical farm describes the specific farm type (crops or livestock) and if the resource endowments (technology, labour skills and management practices) of the typical farm are a good representation of the group of farmers (Feuz & Skold, 1992).

The typical farm therefore represents the mode of the farms in that region and not the average. The most important aspects represented are farm size, market access, profitability, farming practices and yield expectations. To ensure the farm is a true representation of the geographical region, it is necessary to build the model with producers, economists, scientists and other stakeholders from that region. As they are considered experts in their respective fields and it is necessary for them to reach a consensus on all the components of a typical farm in the region. The typical farm enables producers to view the impact of farm-level decisions on the farm's profitability. These decisions range from changing farming practices to capital investments (Knott, 2015).

2.5 Low-chill apples

Most of the world's apple production takes place in areas that are mostly suited for medium to high cultivars (Castro, Cerino, Gariglio & Radice, 2016). This limited the area that could be used to cultivate apple orchards; hence low-chill cultivars were developed. These cultivars enable producers to produce apples in areas that have warmer winter climates. For the purpose of this study it is important to review the existing literature on low-chill apple cultivars to identify the characteristics and to gain a better insight into the breeding process. This section focuses on research conducted by various researchers in different countries focusing on the production of low-chill apples in warmer winter regions.

2.5.1 Introduction

As previously mentioned, the breeding of low-chill apple cultivars was conducted due to the limited production area for normal cultivars. Literature with regards to these cultivars is limited. However, studies have been conducted in Argentina and Ethiopia where scientists explore the potential of low-chill cultivars. It is important for producers to have a thorough understanding of past experiments so that they can cultivate these apples successfully. Below, the most important findings will briefly be discussed and then the focus will be placed on the breeding of low-chill apple production in South Africa.

2.5.1.1 Argentina

A study conducted in Argentina researched the reproductive behaviour of three low-chill cultivars, namely: Eva, Caricia and Princes (Castro *et al.,* 2016). These cultivars are grown in areas that receive less than 350 cold units, which are much less when compared to the 1031 cold units Golden Delicious apples receive. The fruit set of the cultivar experienced moderate to high rates by 'selfing' (self-pollination) in the mild conditions. However, fruit and seed set could be improved under cross-pollination, which indicates that the cultivars require cross-compatible apple cultivars to ensure a significant yield in the growing seasons. The study highlighted the importance of chilling accumulation for the successful production of the apples. In a growing season when the apples experience fewer chilling units, the blooming period of the flowers are delayed which reduces the seed set. This resulted in a delay or partial overlapping of full-bloom periods and it could be linked with the poor cross-fertilization which was experienced. Therefore, the geographical location for producing low-chill cultivars is one of the most important factors in determining the quality and yield of the apples. The fruit set between the three cultivars was over 30%, which indicates the cross-compatibility of the cultivars. 'Selfing' was also able to achieve high fruit sets; however, this did vary between seasons which could decrease the quality of the fruit in different growing seasons. The study concluded that cross-pollination would ensure a higher fruit set with superior quality fruit. However, full-bloom periods of the various cultivar pairs do not overlap by more than 50% in each growing season. This highlights the need for pollen donors or chemicals to break the bud's dormancy (Castro *et al.,* 2016).

2.5.1.2 Ethiopia

Ethiopia is considered the most important apple-producing nation in East Africa (Melke *et al.,* 2016). It has the conclusive resource endowments for apple production and the area planted in the highlands has increased drastically. To expand their knowledge and understanding of apple production, research is being conducted to improve their cultivation practices.

The effect of a heavy crop load on the overall quality of apples in the Ethiopian highlands was studied (Melke *et al.,* 2016). There were three low-chill apple cultivars involved in the study, namely: Dorsette Golden, Princesa and Anna. Results indicated that a heavy crop load had a significant negative impact on the fruit in terms of weight, starch content and soluble sugar (Melke *et al.,* 2016). This negative impact also had a detrimental effect on the productivity of the trees in the next growing season. To ensure that the fruit quality is high, producers should conduct early fruit thinning with the lowest possible load. Keeping the number of fruits per spur between one and three ensured that the quality of the apple internally and externally was not compromised. However, two fruits per spur is considered to be the best for the apple's size and quality. The study highlighted an important farming practice (early fruit thinning) that should be implemented by the producer to ensure that the quality of the low-chill apples is not negatively affected.

2.5.2 Purpose for development in South Africa

In 1995, a breeding program was initiated by the South African Agricultural Research Council in the Western Cape with the focus on low-chill apple cultivars. This program was due to the prolonged dormancy symptoms that appeared in apple trees in the Western Cape regions that did not have enough chilling units for large scale commercial cultivars (Schmidt *et al.,* 1999). According to Schmidt *et al*. (1999:282) the purpose of the study was two-fold: "...firstly to investigate the relative importance of genetic and environmental variance in chilling requirements of apple seedlings and, secondly, to explore the applicability of early screening to quantify chilling requirements at a young seedling stage for the purposes of selection." When a tree's chilling requirements are not fulfilled in the winter, budburst can be delayed which results in problems such as uneven fruit size, low fruit set, longer flowering periods and ultimately lower yields; this phenomenon is called delayed foliation (Allderman *et al.,* 2011; Saure, 1985; Cook & Jacobs, 1999).

The Western Cape is the largest apple producing region in South Africa, however in many areas the winter seasons are not cold enough for proper plant growth. That is why producers currently make use of chemicals to ensure a more uniform bud break so that a higher fruit set and fruit quality can be achieved. Producing cultivars that are properly suited for these areas would be greatly beneficial to the producers. The results indicated that 30% of variance in the number of buds sprouting and 62% for the time of sprouting was linked to the genetic profiles of the different seedlings (Schmidt *et al.,* 1999). The results also indicate that there is a substantial variation between plant genetics and its chilling requirements. Early screening can in fact be used to identify individual young seedlings which can be modified for the warmer winter regions and to improve the overall genetics of the trees.

2.5.3 Benefits and potential challenges

For producers to cultivate low-chill apples, they would require an analysis of the benefits and potential challenges of producing these cultivars. As these apples have recently been introduced, the area under production is still small and the successfulness of these apples cannot yet be confirmed. However, within the next ten years it will be possible to conduct more studies to see the effectiveness of low-chill cultivars.

The most important benefit of these apples is that they do not require a high amount of cold units to ensure a good quality apple. This increases the areas in the world that are now suitable for apple production. Countries that had to import the majority of their apples can now increase their local supply and support the growth of their apple industry. In South Africa, the majority of apple production occurs in the Western Cape area. Harvesting of apples starts from the middle of February up until June. The top-quality apples are exported and then the rest are stored in "controlled atmosphere storage" (CA) to ensure a constant supply of apples throughout the year. The quality of these apples declines, as they are stored for months on end. The benefit of the low-chill apples is that they can be produced in warmer winter regions and harvested at a different time period when there are no fresh apples on the market (Von Mollendorff, personal communication 2018). This could greatly benefit these producers, as they can enter the market with a fresh product before the other apple production areas start to harvest.

A great challenge for low-chill cultivars is that they can only be stored for a maximum of two months (Von Mollendorff, personal communication 2018). Hence, the producer should have marketed and sold these apples before they are harvested. The aim of the low-chill apples is to sell it while it is still fresh so that there is no need for CA storage. If the apples are going to be stored the producer will lose his competitive advantage as the rest of South Africa's apple producers will start harvesting and, unlike the low-chill apples, their apples can be stored for a long period of time.

2.5.4 Potential scope

Low-chill apples have the potential to increase the size of the South African apple industry. Should all the assumptions hold, producers in warmer winter regions could consider the production of these apples. Producers can replace less profitable enterprises with apple production or simply just expand the existing farming system to include the production of apples. For instance, apples could substitute the production of pears as they have higher yields and receive similar prices (Hortgro, 2017).

According to Hortgro (2017), South Africa is a net exporter of apples, this is illustrated in Table 2.1. This is a positive sign as producers are able to receive higher prices for top quality fruit exports, however, as previously mentioned, this results in local consumers not having access to top quality fresh apples. Low-chill apples can fill this gap as they can be harvested from as early as mid-December which is about two months before any other apples are harvested (De Wet, personal communication, 2018). Considering that they will be the only fresh apples on the market, consumers may be willing to pay a premium for these apples. This could potentially lead to a more profitable farming system.

Table 2.1: Crop distribution apples

Year Jan-Dec	**Total production (Ton)**	**Local market (Ton)**	**Exports (Ton)**	**Processed (Ton)**	**Dried (Ton)**	**Change in total production (%)**
2008	757 679	180 480	338 647	236 833	1 720	
2009	800804	205808	332684	261191	1120	6,00
2010	753 152	221131	298559	232473	990	-6,00
2011	768098	231285	318966	216257	1590	2,00
2012	813 191	209198	358457	244427	1110	6,00
2013	907826	203181	434248	267436	2960	12,00
2014	792 324	210303	339096	239765	3160	-13,00
2015	924162	213931	413757	293724	2750	17,00
2016	902 131	211556	425325	265050	200	-2,00
2017	940346	209631	417794	312681	240	4,00

Source: Hortgro, 2017

2.5.5 Growing areas

The leading provinces with regards to apple production are the Western Cape, Eastern Cape and the Free State (Hortgro, 2017). This is due to the cold winters in specific regions that accumulate enough cold units for apple production in certain regions. The introduction of low-chill cultivars has created the opportunity for other regions in these provinces and other provinces to be identified as possible growing areas.

Mookgophong, previously called Naboomspruit, in the Limpopo province is the area in South Africa where the majority of low-chill apple orchards have been established (Von Mollendorff, personal communication, 2018). Other potential growing areas include Elgin in the Overberg region and the Warm Bokkeveld. These areas experience sufficient amounts of cold units for low-chill cultivars. This study focuses on the Warm Bokkeveld as a potential growing area.

2.6 Conclusion

To answer a research question correctly it is important to consider all of the past research conducted on similar research questions. This enables the researcher to determine what the correct tools to answer the research question are. Therefore, the focus of this chapter was to review past literature on various topics relating to the study at hand. To gain a greater understanding of what needs to be done, and how it can be done.

A farm is an extremely complex system which consists of multiple components, such as: input and output prices, production levels, capital investments and environmental influences, etc. These components are interrelated and a change in one component has an influence on the outcome of the entire farm system. Therefore, it is important to follow a systems approach to answer the research question. A systems approach takes a holistic view of the system and does not separate components from the whole. The development of computer software allows researchers to conduct complex calculations to analyse the farming system via models and simulation. A model allows us to view something that would otherwise be unobservable. The credibility of a model is determined by the number of variables that are included. A model can assist producers by improving their decision-making abilities. This is done by evaluating the outcomes when producers change input data and assumptions; these evaluations are done through a simulating procedure. Simulation modelling enables producers to run different scenarios which indicate the outcome of each scenario and in such a way the producer can make better informed decisions.

For this study, budget models will be used to evaluate the profitability of various farming systems. A whole farm multi-period budget model is efficient when it comes to evaluating a farming system over an extended period of time. The model takes a set of inputs; it then conducts specific calculations and then gives information outputs. The model shows the interrelatedness of components and how changing the data inputs have an influence on the information outputs. The most important prerequisite for a successful whole farm budget is that the modeller should have an in-depth knowledge of the farm system that is being modelled. Spreadsheet programs are most commonly used to conduct complex calculations to determine the impact of changing input data or assumptions in the model. Aggregating and averaging of agricultural production into broad geographic and commodity output groups can lead to some very misleading perceptions about farm-level economic impacts. Hence the development of typical farm models. A typical farm model represents a group of farmers who are conducting the same type of farming activities in a homogenous region. Some important aspects include farm size, market access, profitability, farming practices, resource availability and yield expectations. Producers can then model the typical farm to evaluate the impact of their decisions on the farm's profitability levels.

The next section focuses on low-chill apples and the development and testing of these apples in various countries. Normal apple production requires a cold winter season to accumulate enough cold units for the apple to properly grow. The development of low-chill cultivars enables the production of apples in areas that have relatively warmer winter climates. South Africa has limited areas that cultivate apples. These low-chill apples offer the opportunity for producers in various production areas to engage in apple production. A major benefit of these apples is that they can potentially be harvested up to two months (depending on location) before the rest of the South African apple producers start harvesting. At the time of harvest, these apples are the only fresh apples available on the market in South Africa; all other apples have undergone CA storage for an extended period of time. A potential challenge lies in the apples poor ability to be stored and sold at a later stage. However, the purpose of these apples is to sell them before they have to compete with other South African apples. Two areas that have been identified for low-chill apple production include the Mookgophong area in Limpopo and the Warm Bokkeveld region in the Western Cape. The focus of this study is on the production of low-chill apples in the Warm Bokkeveld.

The following chapter will go into more depth as to how the model was developed for the Warm Bokkeveld. An overview of the Warm Bokkeveld, as well as a thorough description of the Warm Bokkeveld and its economic importance, will be discussed. This section will also explain how the typical farm was described and validated. All models require a set of assumptions for the model to be operational. The assumptions with regards to crop yields, expected costs and product prices, etc. will be discussed and validated. The chapter also describes the development of the whole-farm, multi-period budgeting model that will be used to compare the profitability of alternative production systems.

Chapter 3: Model development for a typical farm in the Warm Bokkeveld

3.1 Introduction

Chapter two gave an overview on various topics that are related to this study. Farm systems are extremely complex, therefore it was determined that the research question would require a systems approach. The best method to model this system is through a whole-farm multi-period budget model. The budget model allows the researcher to determine the impact of various decisions on the overall profitability of the farm. In Chapter two the purpose of development of low-chill apples was discussed, as well as the potential benefits and challenges facing these apples. The potential areas where the apples could be cultivated were also discussed. However, for the purpose of this study the Warm Bokkeveld will be the region where the possible cultivation of low-chill apples is tested.

Chapter two determined how the research question should be answered and Chapter three focuses on the process of answering the research question. To conduct a financial analysis of low-chill apples in the Warm Bokkeveld a typical farm has to be identified. The typical farm represents the farming activities of similar producers in a homogenous area. The farm represents the modal farm in the area and can be used to determine the impact of a change in practices or crop varieties on the overall profitability of the enterprise. In Chapter three, the procedure that will be followed to identify and validate the typical farm will be discussed. This includes all aspects from the physical description of the farm, to the procedure of how the budgeting model will be developed to calculate the expected profitability of the whole farm. This chapter is critical to understanding how whole-farm budgeting models can be used to determine the financial viability of implementing a new crop. The model enables the understanding of the impact that a change in crop enterprises has on the entire farming system.

To conduct a whole-farm budget, certain assumptions have to be made. These assumptions include input costs, prices and yields, etc., and how they were defined and validated is also discussed in the chapter. The general purpose of Chapter three is to explain how the typical farm and budgeting model that was identified in Chapter two was developed.

The first part of the chapter gives an overview of the Warm Bokkeveld. The overview includes the economic importance and crops that are produced in the region. Section 3.3 and 3.4 explains how the typical farm in the Warm Bokkeveld was described and validated. This includes the parameters of the farm, namely; crop varieties and land utilization, assumptions regarding yields, costs and prices and finally, low-chill apples and the assumptions regarding prices and costs of producing these apples. The last part of the chapter discusses how the budgeting model is developed into the excel spreadsheet and the calculations conducted throughout the model. After this a brief conclusion on the findings of Chapter three is given.

3.2 Introduction to the Warm Bokkeveld

The Warm Bokkeveld is a fertile valley in the Western Cape. The region consists of two towns namely Ceres and Prince Alfred Hamlet; these towns are surrounded by a series of mountains. The Warm Bokkeveld accumulates up to 1007 daily positive chill units (DPCU), which makes it a favourable area for the production of deciduous fruits (Carmichael, 2011). In this section the historical background of the Warm Bokkeveld will be discussed, as well as the economic importance of the region in terms of its contribution to deciduous fruit production. The crops used in the model will be also be discussed.

3.2.1 Economic importance of the Warm Bokkeveld

South Africa is one of the leading deciduous fruit producers in the Southern Hemisphere (Theron, 2012; Sikuka, 2016). Statistics indicate that the deciduous fruit industry contributes R 12,35 billion to the country's GDP (Hortgro, 2017). The industry employs around 107 371 permanent workers and contributes to a better standard of living for them and their dependents which is around 429 485 people (Hortgro, 2017). The total area of deciduous fruit planted in South Africa is around 79 912 ha and a significant percentage of this area is planted in the Western Cape Province (Hortgro, 2017). This indicates the economic importance of the deciduous fruit industry to the country's economy.

As previously mentioned, the Warm Bokkeveld is an important region for the production of deciduous fruit. The following list indicates the area planted of various crops in the Ceres area (including the Warm Bokkeveld and Koue Bokkeveld) (Hortgro, 2017):

- 7 452 ha (30,85%) of South Africa's apple production area.
- 4 551 ha (37,11%) of South Africa's pear production area.
- 883 ha (16,22%) of South Africa's peach production area.
- 864 ha (41%) of South Africa's nectarine production area.

As indicated, the region contributes to the overall deciduous fruit industry. However, the entire Western Cape is considered vulnerable to climate change (Wand, Steyn & Theron, 2007). Predictions indicate slight temperature increases over the next three decades coinciding with decreasing winter rainfall. This could lead to a rise in socio-economic challenges in the Western Cape as the climate for agricultural production will become increasingly challenging. Climate change could directly impact the size and other quality-determining characteristics of the yields as chilling units will likely decrease (Wand, Steyn & Theron, 2007). Damage due to sunburn could occur more frequently, fruit could have poorer colouring and trees will undergo longer drought periods. Producers will need to account for this and adapt their farm systems to ensure that they can continue producing deciduous fruit in the future. A strategy to decrease the risk of climate change could involve the cultivation of lower-chill cultivars, which are better suited for an area that is facing increasing temperatures. The cultivation of low-chill apples could ensure that the Warm and Koue Bokkeveld remain important regions for the production of deciduous fruit.

3.2.2 Crops

The crops found on a typical farm in the Warm Bokkeveld were identified and validated through discussion with CFG and producers from the region. The crops found on a typical farm in the Warm Bokkeveld include apples, pears, nectarines and peaches. These crops are suited for the area due to the cold climate conditions in the winter area. The crops require a high number of cold units to produce a good yield of high-quality fruit. In previous years, vegetables such as onions were more popular, but producers are replacing vegetable production with the production of stone fruit as they are higher value crops.

The various crops and the varieties of each crop planted will be discussed in detail in section 3.3.3. The characteristics of the varieties are important as they influence the yield and quality of each variety. Yield is an important characteristic of the variety that influences its profitability. The expected yield for each variety is multiplied with the expected price it will receive to calculate the gross value of production.

In the model the input and establishment costs of apples and pears are different, but for each variety under the specific crop the costs are the same (Granny Smith apples have the same per hectare costs as Panorama Goldens). However, nectarines and peaches have the same input costs for all the varieties, as indicated in Hortgro (2017). The cost also has an influence on the profitability, as the gross value of production is subtracted from these costs to calculate the gross margin of the specific variety. However, the yield and price expectations of the variety have the biggest influence on the variety's profitability.

3.2.3 Quality issues with cold requirements

Temperature and light exposure during fruit growth are the two most important variables when it comes to the quality of pome fruit, postharvest (Carmichael, 2011). The Warm Bokkeveld's climate is not as optimal as the Koue Bokkeveld, which explains why the Koue Bokkeveld region produces better quality pome fruit. If the fruit does not experience a sufficient amount of cold units during the winter it can have a highly negative impact on the yield and quality of the orchard (Alderman *et al.,* 2011). If a tree does not receive enough cold units, budburst can be delayed and this results in uneven fruit size, lower fruit set and longer flowering periods. This phenomenon is known as delayed foliation (Alderman *et al.,* 2011).

The issue with cold requirements has led to the breeding of low-chill cultivars that are more suited for regions with a lower amount of cold units (Schmidt, 1999). These cultivars could be the solution to the quality issues producers are facing when their orchards do not accumulate enough cold units. Although the production of these cultivars has not taken place in the Warm Bokkeveld, the results from the Mookgophong region in the Limpopo Province are promising. The Mookgophong region accumulates less cold units than the Warm Bokkeveld, which could indicate that the production of the apples in the Warm Bokkeveld could be even more successful.

3.3 The typical farm for the area

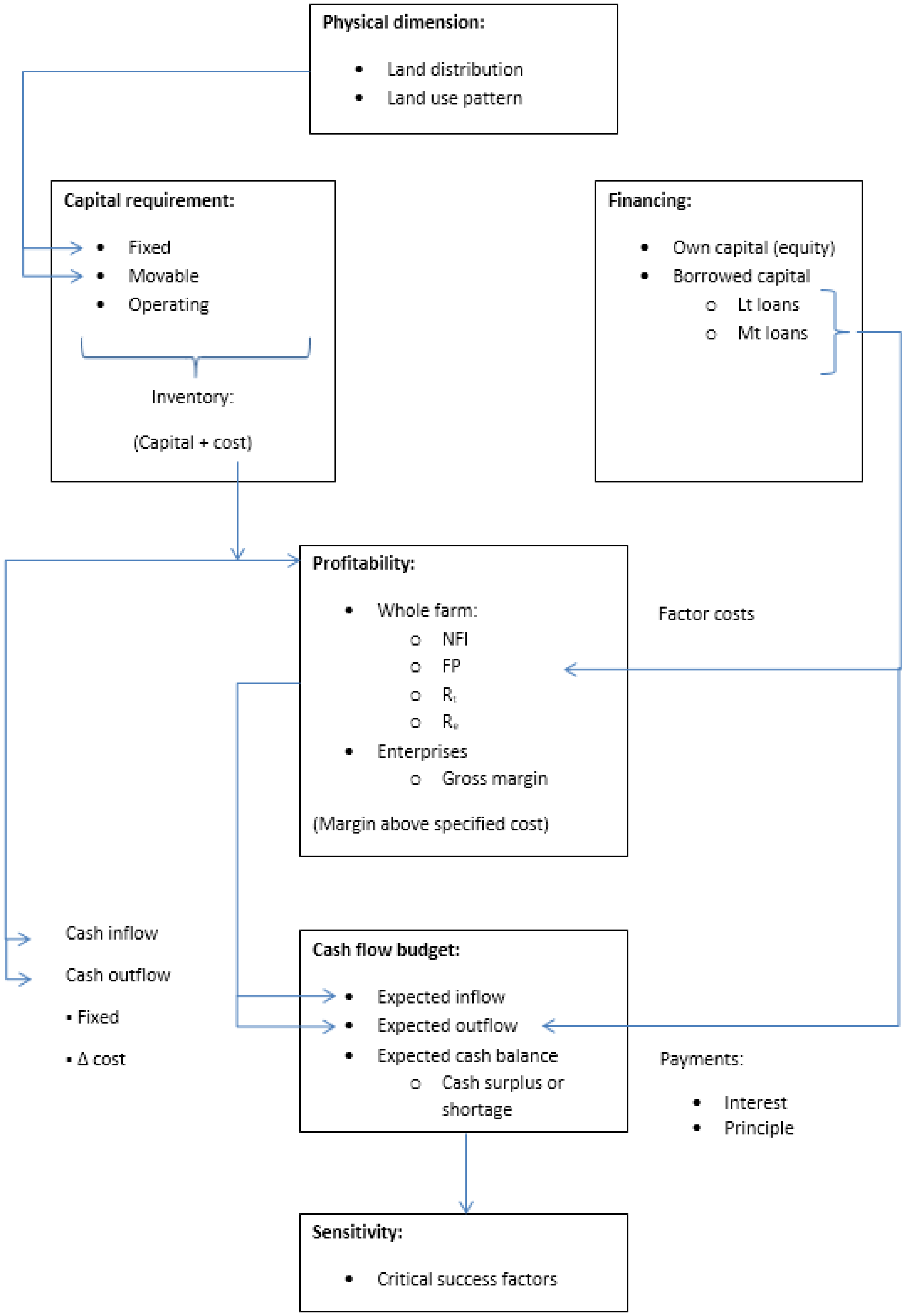

Figure 3.1 Components of whole-farm budgeting model

A typical farm is used to represent the farming activities that producers in a homogenous area engage in. It is important to note that the farm represents the mode of farms in the area and not the average of all the farms. Constructing a typical farm allows producers in that region to have a greater insight into the impact of their decisions on the overall profitability of the farm being modelled. As mentioned in Chapter two, it is necessary to build the model with experts in the region where the typical farm will be used to conduct the study. A financial analysis can then be conducted on the typical farm to determine the current financial situation, and then also to model the outcome of altering crop distributions and other production systems or farming practices.

Figure 3.1 highlights all of the various components that make up the whole farm budgeting model. The figure will be used to demonstrate how the various components are incorporated into an excel spreadsheet. Sheets within the workbook are used to represent the various components that make up the budget model. Throughout the sheets, calculations are conducted and many of these calculations are interlinked with other sheets, hence a change in one calculation can replicate changes throughout the whole spreadsheet.

3.3.1 Identification and validation

The typical farm in the Warm Bokkeveld was constructed and validated through communication with Ceres Fruit Growers (CFG) and producers in the region. Most producers in the Warm Bokkeveld conduct business with CFG. CFG provides services to producers such as packaging, marketing and distribution. CFG have conducted multiple studies in the region and have an in-depth knowledge of what the typical farm in the area would look like (Odendaal, Personal Communication, 2018). Through discussions with CFG and producers the typical farm in the Warm Bokkeveld was modelled. Then the farm changes were made and these changes were validated by CFG and the producers. The most important aspects discussed include the following: farm size, ownership, irrigation, prices and crop distribution.

3.3.2 Parameters (physical, ownership, land price and irrigation)

The parameters of the typical farm include the physical dimensions of the farm, the percentage of ownership, the irrigated area and the land price. The parameters of the typical farm were discussed and validated with CFG and multiple producers in the Warm Bokkeveld. It was established that the typical farm in the Warm Bokkeveld consists of around 500 ha of total land. This is subdivided into different sections, namely: cultivated area, irrigated land and non-arable land. The cultivated area consists of the land where the orchards/crops have been established. The cultivated area is split up into different crops and crop varieties. As crop varieties have different characteristics (yield and prices), these different characteristics are included in the model to calculate the profitability of each variety. The cultivated land has the highest monetary value as a lot of capital is required to establish the orchards. Irrigated land consists of land that can be used for production but has not been established for cultivation; this land has water rights and can be used when cultivated land is taken out of production to restore the land quality (Meiring, Personal Communication, 2018). This land is not as valuable as cultivated land. Non-arable land includes the areas on the farm that cannot be used for production such as roads, buildings, dams and riverbeds.

The typical farm is entirely owned by the producer and therefore he is responsible for all of the operations and is entitled to all of the returns made during the production year. The price of land in the region is considerably less than the Koue Bokkeveld. The value of the different categories of land was established through communication with CFG and producers in the Warm Bokkeveld.

The physical dimension of the farm is critical in the model as it forms the basis of all production and investment activities conducted by producers. In Figure 3.1, land distribution refers to the land that is divided into the different categories that were mentioned above (cultivated, irrigated and non- arable). In the model, land was distributed into the different categories and each category has a different value per ha. These different values are incorporated to determine the total value of the farm. The value of the farm is required in the model as it makes up the biggest portion of the capital requirement that is necessary for the producer to invest in the farming operation. Along with land, assets such as machinery, buildings, equipment and vehicles are necessary to run a farm. The total value of these assets is used to determine the total capital the producer requires to start farming. When the total capital requirement is calculated the next decision is how the farm is going to be financed. The financing component discusses the percentage of own to borrowed capital. The borrowed capital in the model is a long-term loan, and this loan is repaid over a period of twenty-five years. The loan repayments are directly related to the profitability component. The percentage of own to borrowed capital was determined through discussions with CFG and multiple producers in the Warm Bokkeveld.

3.3.3 Crop varieties and land use

Pome and stone fruit orchards are considered a long-term investment as the trees take a few years to come into full production and they are able to bear fruit over a long period of time after being planted. Hence, it is essential for the producer to invest in the best crop varieties for that area. Deciduous fruit production has been well documented in the Warm Bokkeveld region by the producers and they are more aware of which varieties are better suited for the environment. This allows the producer to replace the less productive or less profitable varieties with varieties that are able to generate higher returns over multiple periods. The crop varieties that are studied in this budgeting model were gathered from CFG and from producers in the region.

The distribution of crop varieties has a major impact on the overall profitability of the farm as different varieties have different characteristics (yields and prices). In the excel spreadsheet there are different sheets used to calculate the profitability of each variety. The model calculates the varieties' gross margin by subtracting the directly allocatable variable costs from the gross production value. The calculation of gross margins is important when producers want to compare the profitability of different varieties. In this study a comparison of which crops or varieties are more profitable on a per hectare basis were carried out. From

Figure 3.1, it can be seen that crop varieties and land use form part of two components namely: physical dimension and profitability. In the model we can alter the distribution of crop varieties (how many hectares are allocated); this instantaneously changes the gross margins of the enterprises that are altered and as a result it impacts the whole farms profitability.

The farm production consists of pome fruit,namely: apples and pears. There are three apple cultivars, namely: Panorama Goldens, Royal Beaut and Granny Smith. Seven pear cultivars are included, such as Forell, Bon Chretien, Packhams, Early Bon Chretien, Abate Fetel and Rosemarie. The stone fruit used in the model are peaches and nectarines. The two peach cultivars used are Keisie and Oom Sarel; both of which are used for canning. Nectarines did not consist of a specific cultivar but were simply included as nectarines. The area allocated to each cultivar is discussed in the following chapter.

3.3.4 Yield assumptions

The most important components required for the calculation of a crop variety's profitability is the expected yield and price. These two factors have a direct influence on the gross value of production for a given variety. When constructing a financial model it is important to use accurate information on a cultivar's yield capability. In the model the yield assumptions were established through using data from CFG, multiple producers and Hortgro statistics.

Yields can vary between farms as some producers are more efficient than others. However, for the typical farm the values were identified and validated with the stakeholders involved. A tree reaches full-bearing capacity after a few years, normally five to six years. Therefore, it is important to account for the orchards age when calculating the gross margins of the crops. In the model this was achieved by assigning a percentage of the yield that can be achieved in a given year, based on the age of the orchard. The first two years the trees do not bear any fruit. In year three the tree bears around 30%, year four is 70% and from year five up until twenty-five, the tree bears fruit at 100% of the expected yield. It is important to note that these percentages are not representative for all cultivars.

Referring to Figure 3.1, the profitability component consists of the whole farm's profitability and the enterprise's profitability. In the excel spreadsheet, the yields of the crops are given in the physical description of the typical farm. These yields are linked to individual sheets that are allocated to the different crop varieties. Altering the yield assumption of a specific crop variety will have an instantaneous effect on the gross margin of the enterprise, which will have an effect on the whole farm's profitability.

3.3.5 Price and cost assumptions

The second factor used in calculating the gross production value of a crop is the price that will be paid per ton. Price is considered an external factor as a producer can have no direct influence on the price that he will receive for his produce. The prices for the various crop varieties were identified through communication with CFG, Hortgro's statistics and multiple producers (Odendaal, Personal Communication, 2018). Table 3.1

highlights the different price categories that the yields will be divided into. The crops are graded into different categories and each category has a different price. The different categories are: Class 1 export; Class 1 Local; Class 2; Class 3; Canned Direct; and Juice Direct.

Pack-out percentage is the percentage of the total yield that can be classed into the different classes indicated below. The remaining percentage of the yield will either be canned or juiced. The percentages were identified and validated through communication with CFG and producers in the Warm Bokkeveld. The pack-out percentage has a direct impact on the profitability of the varieties as higher prices can be received for well-graded fruit than fruit.

Table 3.1 Price and price categories for Panorama Golden apples

Apples	Packaging %					Expected price (R/ton)			
	Ton/ha	Class 1 Export	Class 1 Local	Class 2	Class 3	Class 1 Export	Class 1 Local	Class 2	Class 3
Panorama Golden	75	60%	30%	5%	5%	R 6 000	R 4 000	R 500	0

There are a few cost components involved in the calculation of a crop's gross margin. These include variable costs such as input costs before harvesting and harvesting costs, and also establishment costs which are conducted in the year that the orchard is planted. Input costs are the costs that are necessary to produce; the input costs are variable, as they increase or decrease depending on the level of usage. These costs were identified and validated by making use of CFG's data, discussions with multiple producers and Hortgro's statistics. The input and establishment costs for apples, pears, peaches and nectarines were given and they were allocated to the appropriate varieties. Pre-harvest input costs include the following: fertilizer, herbicides, pesticides, fuel and irrigation. Harvesting costs include seasonal labour, packaging and storage costs. These costs increase or decrease depending on the size of the harvest. Establishment costs are incurred in the year that the orchards are planted. Costs that are involved in this process include land preparation, drainage systems, trellising systems, irrigation systems and plant material. Annexure F shows the budget used by Hortgro for pome and stone fruit. Not all of the cost factors from Hortgro were incorporated into the budget model. The per hectare production costs for apples are included in Annexure E. The production costs were calculated in the spreadsheet.

Producers aiming to improve efficiency would focus on managing their inputs more efficiently. Input costs have a direct impact on the gross margins of a crop. Input costs such as fertilizers and herbicides are influenced by the exchange rate between the Rand and the US dollar. This is because these inputs are imported and a weaker currency means more expensive input costs. The same is true for fuel; it is highly influenced by the oil price and by the country's tax levels on fuel. Producers therefore have no influence on the price level of these costs, but they can manage the quantity of inputs that they use.

In the excel spreadsheet, the costs are calculated on a per hectare basis. To calculate the total of the input costs, the costs per hectare are multiplied by the hectares planted of the specific variety. These calculations are calculated over the 25-year period for each crop variety. The establishment costs are also calculated by the same method by multiplying the costs per hectare with the amount of hectares established. The gross margin of each crop variety can then be calculated in the model by a simple equation. The input and establishment costs have a direct influence on the profitability of the whole farm enterprise.

3.3.6 Criteria for profitability

The purpose of this study is to determine the financial feasibility of low-chill apples in the Warm Bokkeveld. To do this the profitability of various projects (farming systems) have to be compared. The profitability of the various projects will be compared using the internal rate of return (IRR) and the net present value (NPV). The IRR is calculated as a percentage return on the initial capital investment of a project. The IRR is the rate at which future net cash flows can be discounted to a present value of zero (Hagemann, 1990). The NPV is a monetary value that is calculated by discounting the expected future cash flows of the project to its present value (Knott, 2015). Using both criteria is more beneficial as sometimes the results could be misleading (for example a project with a large initial investment could have a low IRR but a high NPV, meaning that the project generates a lot of value from a large investment). Using both criteria is effective for measuring the change in the whole farm's profitability. Although it is better to use both criteria for comparing profitability, for the typical farm it would be possible to only use the IRR or NPV as a measurement of profitability. This is because both of the alternative production systems use the same baseline model. In other words, the aim is to assess the expected financial implications of a change in production systems, but on the same investment.

3.4 Low-chill apples

The production of low-chill apples in South Africa has only recently been conducted on a commercial scale. The first orchards were planted in 2016 in the Mookgophong region (De Wet, Personal Communication, 2018). Hence, the orchards are not in full production yet. However, the initial results of these orchards are promising. To incorporate the production of these apples into the model, numerous assumptions have to be made. To get an accurate representation of the performance of the apples in the model the information was studied and validated by communication with experts in different fields. The experts included Dr Labuschagne who started the breeding program for low-chill apple cultivars in South Africa around eighteen years ago, the CEO of Culdevco, Dr Von Mollendorff, which is the company that supplies the plant material to producers, and the CFO of Marlo farms, Louis de Wet; who are the leading producers of low-chill apples in South Africa.

3.4.1 Assumptions (yield and price expectation)

The assumptions for yield and prices for low-chill apples were more complicated than the assumptions for the other crop varieties. This is because the low-chill apple industry is relatively new compared to the existing apple industry. The performance of these low-chill apples will be monitored in the coming years to accurately gather data on the yields that are harvested, input costs and the prices obtained in the market. The yield and price expectations were derived from personal communication (Van Mollendorff, Personal Communication, 2018; De Wet, Personal Communication, 2018). Separate discussions were held with the experts and the assumptions were identified and validated by consensus.

The time of harvesting has a major impact on the gross value of production, as producers in similar regions harvest at the same time. As mentioned in Chapter two, a major benefit of low-chill apple production in the Warm Bokkeveld is that it can be harvested around one month before the rest of the producers start to harvest the first of other apple varieties. Marlo Farms in the Mookgophong region start harvesting in the beginning of December which is two months before the Western Cape producers start to harvest. They receive a high price for their product as there are no fresh apples on the market. In the Warm Bokkeveld, the apples could potentially be ready for harvest from the middle of January and would still be able to receive a good price before the other apples come into the market. The producer should market and sell these apples before the standard crops have been harvested. This is to ensure that the low-chill apples do not have to compete with the other apples harvested in February (Royal Gala), as they have a much greater storage capability.

Therefore, the assumption of harvesting in the first to second week in January is the most important when it comes to the price expectation of the apples. Discussions were held to validate the price assumptions for these apples. The Low-chill cultivars used in the study are from the Afri-Range; the specific cultivars are Afri-Glo and Afri-Blush. The assumptions are that at full-bearing capacity producers should be able to harvest 90-100 ton/ha, and the price for the cultivars will vary between R 7 500/ton and R 8 500/ton (De Wet, personal communication, 2018; Meiring, personal communication, 2018). Discussions with CFG were held to determine the price producers could receive should they harvest these low-chill apples in the first two weeks of January. After all costs are deducted, producers could receive up to R6 000/ton for Class 1 apples (Odendaal, personal communication, 2018).

The yield and prices of low-chill apples will have a direct influence on the profitability of the whole farm. The excel model enables the user to substitute different crops or crop varieties to compare the profitability on the whole-farm between them. In this research project there are two alternative production systems; production system 1 consists of a typical farm with a typical crop distribution and in production system 2, various pear and stone fruit cultivars were substituted with low-chill apples. The model caters for assessing alternatives as the new crop varieties are linked to their respective production costs and their gross margins are then calculated in the same way. This makes it possible to replace or include new crops in the whole farming enterprise and then to compare the profitability of the various farming systems.

3.4.2 Deviations from standard cultivars

The Afri-range varieties are expected to return higher yields than the standard cultivars. The higher yields and higher prices make it an appealing option should the assumptions hold. For the purpose of this study, the goal is not to compare standard apple cultivars with low-chill cultivars, but to compare the profitability of low-chill apples that could replace pears, nectarines or peaches. The Koue Bokkeveld is an area that is better suited for the production of apples as the region experiences a higher amount of cold units throughout the growing period (Meiring, Personal Communication, 2018). This enables a better quality and higher yield of apples. In the Warm Bokkeveld, the typical farm has more hectares of pear production as the quality of the apples is not as high, as is the case for the Koue Bokkeveld. This is due to the relatively warmer winters in the region, which is why the Warm Bokkeveld has been identified as a region for low-chill apple production.

The low-chill apples are expected to deviate from standard cultivars in certain aspects. These aspects include: colouring, yields, harvest time, price expectation and years of production. The lower cold units affect the colouring of standard cultivars negatively. The cold units in the Warm Bokkeveld are sufficient to ensure good colouring of the low-chill cultivars. The yields of the low-chill cultivars are expected to be considerably higher than that of standard apple cultivars. The earlier harvesting time of the low-chill apples will lead to a better price received. This is due to the lack of fresh apples between December and mid-February. Traditional apple cultivars only bear fruit from year three onwards, low-chill apples are capable of bearing fruit from year two. Although the yields will not be as high, this will enable the producer to have an extra year of apple production and earn an income.

It is clear that there are multiple deviations from standard cultivars; however, it is important to note that these deviations are based on assumptions and there has not been sufficient research conducted on these deviations. The deviations were determined from experimental farm projects, discussions with relevant stakeholders and commercial production results in Mookgophong.

3.5 Model development

A farming system is a complex system consisting of multiple operations and facets that are interrelated. To simulate the farm, a model should be used that can illustrate this interrelatedness between various components in a farming system. In this study the model was constructed in an excel spreadsheet. Spreadsheets enable the user to conduct a series of complex calculations throughout the various sheets to simulate a model. The spreadsheet can be used to link calculations throughout all the sheets to capture the interrelatedness of the various components.

The excel spreadsheet consists of sixteen sheets that are used to conduct various calculations. The first sheet consists of the physical farm description and the crop variety distribution and prices. The farm description discusses the parameters of the farm and how the land is utilized in terms of cultivated land, irrigated land and non-arable land. The crops that are used in the model are listed as well as the characteristics of the varieties such as yield expectancy and the prices receivable for each variety. As previously mentioned, the pack-out percentages for different categories are also given and this component influences the income receivable for each variety. The second sheet consists of the farm inventory, which contains all the assets and their values, expected lifetime, depreciation and running costs. The assets found in the farm inventory include, amongst others, the following: land, fixed improvements, vehicles, equipment and machinery. The next sheet contains information on the capital requirement for the farm. The percentage of own to borrowed capital is given and an amortisation table is constructed to determine the loan payments required to pay off the long-term loan.

The next sheet includes all of the production costs associated with the production of apples, pears, peaches and nectarines. These costs include input costs for pre-harvest and harvesting and the establishment costs per hectare of the different crops. Thirteen of the sheets are used to calculate the gross margins of each cultivar. In these sheets the gross value of production and directly allocatable costs over the 25-year period are calculated. The gross margin sheet allows the researcher to implement a replacement schedule over the 25-year period. Each crop variety is divided up into blocks of equal size. Some varieties have two blocks, whilst others have four blocks. These blocks represent the different orchards that have different ages. These ages determine the income derived from the block; a process explained earlier in the chapter. The various crop varieties' blocks have to be replaced at different stages throughout the 25-year period. This enables the researcher to accurately simulate real-life farming practices.

The fixed costs are calculated on the following sheet. These costs have to be incurred to operate and they do not vary depending on the level of production. The final sheet contains the capital budget. The sheet gives the gross margin of each crop variety that is linked to each respective crop's gross margin sheet. The whole farm's total gross margin is calculated by adding all of the crops' gross margins. The fixed costs that were calculated in the previous sheet are linked to the final sheet and the total fixed costs are calculated. The total factor costs, consisting of hired management and loan payments, are linked to the respective sheets, as well as the total costs of the farm inventory which includes land, machinery and fixed improvements. All of this information is used to determine the net flow of year one and these calculations are repeated up to year 25. The net flows of each year are then used to calculate the IRR and the NPV of the entire project. The results of the calculations will be demonstrated in Chapter four.

The sheets mentioned above are responsible for the calculation of various components of the farm system. All of these sheets are interlinked with each other and the ability to change the data in one sheet can replicate changes throughout the entire spreadsheet. The IRR and the NPV are the critical components that are used to compare the profitability of the various production systems. To illustrate the interrelatedness of the spreadsheet, Panorama Goldens (apples) will be used as an example. If the yield (ton/ha) in the first sheet is increased from 75 ton/ha to 80 ton/ha, the gross production value of the apples will increase for every year in the multi-period budgeting model. This increase will be seen in the Panorama Golden sheet. The variable costs for the variety will also increase as more labour and packaging material will be required. However, the increase in costs will be less than the increase in gross production value; hence the gross margin for Panorama Goldens is now higher. The increase will instantly be shown in the capital budgeting sheet. The fixed costs and the costs of farm inventory will remain the same and as a result the net flow for each year will be higher and the farming system will have a higher IRR and NPV. The most important aspect to take away from this example is that a change in one sheet will instantly change various components throughout the rest of the spreadsheet and ultimately influence the profitability (IRR and NPV) of the farming system.

3.6 Conclusion

The purpose of Chapter three was to explain the development of the whole-farm budgeting model. This is necessary to provide the reader with background information as to how the values are calculated and how the different components of a budget model are interlinked. This is also done to represent the systems nature of the farm as a financial system. Therefore, this chapter explains the tool that is used to answer the research question and how the various components of the tool were identified and validated by relevant stakeholders considered experts in their respective fields.

The Warm Bokkeveld was introduced, which is the focus region of this study and is where the typical farm is applied. The economic importance of the Ceres area, which includes the Warm- and Koue Bokkeveld was highlighted. The Ceres area is the largest producer of deciduous fruit in the Western Cape, which has the largest deciduous fruit industry in South Africa. The entire Western Cape is considered susceptible to climate change, and as a result the cultivation of low-chill apples can be implemented to continue the production of apples in the province over the long term. The identification of a typical farm for the Warm Bokkeveld was discussed in detail. The farm was constructed through discussions with CFG and producers from the region. The key aspects discussed were the following: parameters, crop varieties and land use, yield and cost assumptions, and also how profitability is measured. These aspects are important as they have an influence on the profitability of the farm. The farm inventory consists of land, machinery, vehicles and buildings. The value of the farm inventory is necessary to determine the total capital that is required to start the farming enterprise. The total capital requirement component is necessary to determine the financing component, which influences the profitability component.

The production of low-chill apples has only recently taken place on a commercial scale. Hence, there are still some uncertainties with regards to the yields and prices that these apples can obtain. The yield and price assumptions were established and validated through discussions with experts. From the discussions certain deviations were also identified. The benefit of producing these apples in the Warm Bokkeveld is two-fold. The apples are expected to have a higher full-bearing capacity. Also, the apples can be harvested from the beginning of January so the prices they can receive will also be higher than standard cultivars. The last section of the chapter focussed on the interrelatedness of the model and how excel was used to construct the simulation model. The excel spreadsheet consists of multiple sheets that are used for different components for the budgeting model. These different components are interrelated with each other and changes in one calculation or value can influence changes throughout the other sheets. An example was used to illustrate the interrelatedness of the various components. In the example, the yield of a specific cultivar was increased by a certain amount, and it was shown how this increase in yield caused changes throughout the entire spreadsheet.

Chapter four discusses the monetary values of the components of the budgeting model. The components discussed include the capital requirement and profitability. The results of the calculations are discussed in-depth. The most important component is the profitability, as this is the basis of comparison for the two production systems. Therefore, each production system's results are given and analysed and at the end of the chapter they are compared with each other.

Chapter 4: Model application and results

4.1 Introduction

The purpose of the study is to compare the profitability of various farming systems in the Warm Bokkeveld based on the inclusion of low-chill apples. To do this a typical farm was constructed through discussions with a wide-range of experts that ensured the typical farm was representative of a farm in the Warm Bokkeveld. The development of the whole-farm budgeting model was discussed in Chapter three. The calculation component was also explained so that the reader can comprehend how the complexity of farming systems can be simulated through the model. The model constructed in Chapter three is used to calculate the profitability of two various farming systems, also referred to as production systems, production alternatives or alternatives.

Chapter four discusses the results of the two farming systems that are being compared in the study. The chapter is divided into four sections. The first two sections are dedicated to analysing the results of the farming systems that have been modelled. These sections discuss key components such as capital requirements in the form of farming inventory and the overall profitability results of the farming systems. The physical parameters of the farm remain constant in both alternative production systems. The two production systems are constructed to simulate and compare the profitability of different crop distributions on the same typical farm in the Warm Bokkeveld. Production alternative 1 consists of a crop distribution of apples, pears, peaches and nectarines. Production alternative 2 consists of a farming system that includes the production of low-chill apple cultivars, which replaced a percentage of Forelle pears and Keisie peaches.

The following section compares the profitability results of the production systems. The criteria used to compare profitability are the Internal Rate of Return (IRR) and the Net Present Value (NPV). The next section conducts a sensitivity analysis that is used to simulate various scenarios within production alternative 2. These scenarios are alterations of the assumptions regarding the yields and prices of low-chill apples. The purpose is to incorporate the uncertainty of external and internal factors that can influence the profitability of a farming system. The sensitivity analysis allows the user to view the impact of certain assumption changes on the profitability of production alternative 2, as production alternative 1 does not contain low-chill apples. The chapter closes with a conclusion that summarises the findings of the chapter.

4.2 Model outcome

The whole-farm budgeting model's construction process was described in Chapter three. The model was used to simulate two alternative production systems to determine the overall profitability of each one. This section focuses on the first alternative production system and discusses the outcomes of the various components and the profitability of the farming system. Production system 1 simulated in the model, was of a farm with a crop distribution considered to be typical for the Warm Bokkeveld. The crop distribution consisted of apples, pears, peaches and nectarines. Production system 2 is conducted by making changes to the crop distribution of the typical farm. The physical parameters (farm size and location) of the farm have to remain the same to ensure that the production alternatives are comparable.

4.2.1 Capital requirement

The capital requirement component of a budget model indicates the capital a producer would need to start the farming enterprise. The capital is required to acquire the farming inventory that forms the basis of production activities. The farm inventory sheet consists of the following components: land, fixed improvements, vehicles, machinery and implements. The amount of assets required depends on the size of the farm as a larger farm requires more assets to conduct operations. In the sheet there are details regarding the assets, namely: expected lifetime, current lifetime, purchase price, depreciation and residual value. etc. All of this information was extracted from the Department of Agriculture's "Guide to Machinery Costs 2017/2018" and the earlier edition (2016/2017), as the new guide did not have all of the implement and vehicle information. This information is used to construct a replacement schedule as the assets have to be replaced at the end of their expected lifetime. The replacement schedule makes use of complex calculations that runs over the 25-year period and replaces the asset at the end of its lifetime, should it fall within the 25-year period of the budgeting model. The replacement cost of the asset is its original purchase price minus the residual value that is received for selling the asset.

The total capital that is required for the typical farm is R 31 150 240. The largest part of this investment requirement is in land, and the cost of land varies greatly depending on the area of the land and the production resources that are located on the land. The following section focuses on land, which is the most important production asset for every farming enterprise.

4.2.1.1 Land

Land is the producer's most important capital asset (Van Reenen & Davel, 1989). It forms the basis of all activities that occur in a farming enterprise. The Warm Bokkeveld consists mostly of agricultural land of which the majority is used for the production of pome and stone fruit. As the production of pome fruit is region specific in South Africa, the cost of land in the Warm Bokkeveld is considerably more expensive than for instance land in the Swartland area. This is also because pome fruit is considered a high-value crop, whereas grain crops are not necessarily a high-value crop.

Table 4.1 indicates the land distribution and use for the typical farm in the Warm Bokkeveld. The farm consists of a total size of 500 ha of which 200 ha is arable land. From the 200 ha, 142 ha is irrigated land and the other 52 ha has been established for fruit production. The 52 ha is subdivided between the various crops in the budget model. The crops are divided as follows: 32 ha for pear production, 10 ha for apple production and the remaining 10 ha consists of stone fruit production (peaches and nectarines). The total value of the land is R 26 940 000 which constitutes 86% of the total capital requirement. The cultivated land (52 ha) makes up the largest percentage of total land value. This is due to the large investment that has to be incurred to establish the orchards. The price of cultivated pome fruit and stone fruit land is R 450 000/ha and R 350 000/ha respectively. The irrigated land can be used at the end of an orchard's lifetime when the producer wants to give the land some resting time. This is important because overuse of the same piece of land can result in the degradation of the land, which is bad for the producer and for the environment. Hence, it is important for the producer to farm sustainably to ensure future generations can still farm the land.

Table 4.1 Land distribution and use

Land Distribution	**%**	**Ha**	**Value**
Own land	100%	500	26 940 000
Rented land	0%	0	
Water availability	450000	m^3	1 600 000
Water requirement per ha	8000	$m^{3/ha/year}$	
Ha under production	56		
Land Use	**Number ha**	**R/ha**	**Value**
Arable	200		
Irrigation Land	148	30 000	4 440 000
Cultivated Land	52		
Pome Fruit	42	450 000	18 900 000
Stone Fruit	10	350 000	3 500 000
Grazing	4	150 000	600 000
Non-arable (roads, dams, etc.)	20	5 000	100 000
Crop distribution	**Apples**	**Pears**	**Stone Fruit**
Ha	10	32	10

As previously mentioned, there are three crops that are established on the typical farm. Each of these is divided into a few varieties that have different yields and price levels. The apple enterprise consists of three varieties, pears consist of seven varieties, peaches of two varieties and nectarines consist of one variety. In Table 4.2 the distribution of crop varieties, as well as the percentage the variety constitutes of the total established area for production system 1, can be viewed.

The ability to alter the information in the spreadsheet makes it easy and useful to compare the profitability of the various crop varieties used in the model. Production alternative 1 represents the crop distribution of a typical farm in the Warm Bokkeveld. In Table 4.2 we can see that the typical farm predominantly consists of pear production. This is in contrast to the Koue Bokkeveld where farms mostly focus on apple production.

Table 4.2 Crop variety distribution for production system 1

Crop	Variety	Established (ha)	% of Total established area (52ha)
Pome Fruit		**42**	
Apples	Panorama Golden	3	6%
	Royal Beaut	5	10%
	Granny Smith	2	4%
Pears	Forelle	15	29%
	Bon Chretien	3	6%
	Packhams	5	10%
	Early Bon Chretien	3	6%
	Abate Fetel	2	4%
	Rosemarie	2	4%
	Other	2	4%
Stone Fruit		**10**	
Peaches	Keisie Inmaak	5	10%
	Oom Sarel	2	4%
Nectarines		3	6%
Total		**52**	**100%**

4.2.1.2 Fixed improvements

Fixed improvements consist of buildings and housing located on the farm. The buildings on the farm are used for storage and irrigation. The houses are constructed for the owner of the farm and the permanent employees and their dependants that live on the premises. The storage buildings are used to store inputs such as chemicals (fertilisers, pesticides, etc.), implements and machinery. The other buildings on the farm are used to conduct farming activities such as irrigation houses to control the irrigation schedules and packaging sheds where the harvested crops are stored. In the model, most of the majority of the varieties are harvested and delivered to CFG, where they store, pack and distribute the products.

4.2.1.3 Enterprise budgets

An enterprise budget allows the producer to estimate the revenues and costs of a particular crop. In the study there are three crops consisting of different varieties. An enterprise budget was constructed to calculate the gross margin of each variety in different sheets. The enterprise budget for Panorama Golden apples can be seen in Annexure D. The budgets indicate the gross production value, directly and indirectly allocated variable costs and the resulting gross margin for each crop variety. The gross production value varies depending on the year of production and the variety. Varieties can produce at full-bearing capacity either from year five or six, and from this year the income is the highest. In the first two years after being planted the trees do not bear any fruit, hence the gross production value for those years are zero. From the gross production value, the variable costs are subtracted and the resulting figure is the gross margin of the variety on a per hectare basis. In each variety's sheet, the orchards are divided up into equal blocks, and each block has a different age and has to be replaced at a different point throughout the 25-year period. This allows the model to replicate real-world farming practices, as all orchards are not planted at the same time. In the year that a block is replaced, the total gross margin of the variety will be lower as one of the blocks does not generate an income; a high cost is incurred to establish the new block.

The total gross margin of each variety is added together to calculate the whole farm's gross margin for the year. This calculation is conducted in the capital budget sheet.

Table 4.3 Total gross margins of each variety

Crop	Variety	Established (ha)	Gross margin/ha	Total gross margin
Apples	Panorama Golden	3	R 259 050	R 777 152
	Royal Beaut	5	R 206 219	R 759 397
	Granny Smith	2	R 225 224	R 450 449
Pears	Forelle	15	R 140 588	R 2 108 826
	Bon Chretien	3	R 129 819	R 389 457
	Packhams	5	R 146 363	R 731 817
	Early Bon Chretien	3	R 173 963	R 521 890
	Abate Fetel	2	R 163 088	R 326 177
	Rosemarie	2	R 179 963	R 359 927
	Ander	2	R 179 963	R 359 927
Peaches	Keisie Inmaak	5	R 62 157	R 310 783
	Oom Sarel	2	R 51 344	R 102 689
Nectarines		3	R 96 907	R 290 720

Table 4.3 indicates the total gross margin calculated for each variety. This is the gross margin received for each variety multiplied by the respective number of hectares planted. It is important to note that the values in the table are only achieved in the years where all of the blocks are established and bearing fruit at full capacity. From Table 4.3 it can be seen that Forelle pears and Nectarines have the lowest gross margin/ha. This is due to the low yields that are harvested from these varieties; 45 ton/ha and 30 ton/ha respectively. However, both of these cultivars receive good export prices, R7500/ton and R8000/ton. Forelle is planted on

such a large scale as the climate in the Warm Bokkeveld is best suited for the variety. The varieties with the highest gross margins are Panorama Golden apples and Rosemarie pears. Panorama Goldens have a high yield (75 ton/ha) and receive good export (R6000/ton) and local prices (R4000/ton). These two components are used to calculate the gross production value of a variety. Rosemaries also have high yields (60 ton/ha) and good prices for export (R6000/ton) and local produce (R2500/ton).

4.2.1.4 Whole-farm budget

The whole-farm budget, also called the capital budget, is used to calculate the profitability of a farming enterprise. The budget is conducted over a 25-year period. For every year, the total gross margins of the various varieties are given. These gross margins are linked to the respective enterprise budgets located in the different varietie's sheets. The sum of these gross margins gives the total farm's gross margin.

In this sheet the following components are also calculated: total fixed costs, total factor costs and total capital requirement. These components are required to calculate the annual net flows of the farm. Total fixed costs include permanent labour, maintenance and repairs, bank costs and fuel. These costs have to be incurred no matter the level of production. Factor costs consist of hired management, payments and rented land. For this study, no hired management or rented land was assumed. However, a long-term loan was taken out and the annual repayments have to be included under factor costs. The total capital requirement was discussed in Paragraph 4.2.1 and consists of land, fixed improvements, vehicles and implements. As the budget is conducted over a period of 25 years, the farm inventory's replacement schedule is also included. This schedule indicates in which year various assets have to be replaced at the original purchase price minus the residual value.

The net annual flow is calculated by taking the total farm gross margin for the year and subtracting the total fixed costs, factor costs and capital requirement. This calculation is done for all 25 years and with this information the profitability of the whole farm enterprise can be determined. The whole-farm budget for production system 1 can be seen in Annexure B.

4.2.2 Profitability

In Chapter three the criteria for profitability was discussed in depth. The two criteria used to evaluate the profitability of each production system were the IRR and the NPV. The IRR calculates the percentage growth of an initial capital investment. The NPV discounts the expected future cash flows that would be generated from a certain project back to its present value. The rate at which cash flows are discounted is called the discount rate.

Table 4.4 indicates the profitability results of the first production alternative. The IRR of production alternative 1 is equal to 3,64 %. The IRR has to be compared with the real interest rate to determine if it is a good investment. If the IRR is greater than the real interest rate, then the farming enterprise generated a higher return than it would have if it was invested in the bank or a specific fund. The NPV of production alternative 1 is R5 372 695 which is the value of the future cash flows discounted by the rate of 2,4%.

A considerable amount of time and effort has been placed into the development of the model to ensure that it is accurate. However, there are likely some deviations that occur in actual farming enterprises that could not be captured in the model. The purpose of this study is not to have a 100% accurate representation of the real world, but to compare the profitability of various farming systems. Therefore, even though the IRR and NPV of the alternative production systems are not completely accurate, the results of the two alternatives can determine the more profitable farming system and that will answer the research question.

Table 4.4 Profitability criteria for production system 1

Production system 1	Discount rate	Internal rate of return (IRR)	Net present value (NPV)
Typical farm with standard cultivars	2,40%	3,64%	R 5 372 695

4.3 Modelling outcome with low-chill apples

Production alternative 2 is the alteration of the original model used in the first farming system. In production alternative 2, the crop distribution is altered. The land allocated to pear and peach was reduced by 5ha and 2ha respectively, and low-chill apples were planted in place of the reduced pear and peach area. The spreadsheet makes it easy to change the land utilized for each crop variety. The new crop varieties and their respective assumptions are the only changes that are made to the model. The other dimensions of the farm, such as the cultivated area, have to remain constant as this allows us to compare the various farming systems.

In the physical dimension sheet, the changes are entered in the crop distribution table. The land allocated to pear and peach cultivars are reduced by 7ha and added to the area of low-chill apples. This automatically reduces the total gross margin of the respective varieties. The information of the low-chill apple varieties are entered into the crop distribution table. The information includes: yields, prices, pack-out percentages and area planted. A new sheet is created for each variety; this sheet is linked to all of the information in the physical dimension sheet and is then used to calculate the gross margins of the varieties. The varieties sheets are linked to the capital budget sheet and the total gross margins of each variety is shown here and used to calculate the total farm gross margin. A few alterations to the original model enable the user to simulate a different farming system in an easy way. The changes made will influence the profitability of the farming system.

Table 4.5 shows the crop variety distribution that was used for production system 2. In the scenario, Forelle pears and Keisie peaches were reduced with five hectares and two hectares respectively. The varieties were replaced with two low-chill apple varieties from the Afri-range, namely Afri-Blush and Afri-Glo. Each cultivar had been established on 3,5 ha of land. The varieties were bred by Dr Labuschagne whilst working for the

Agricultural Research Council (ARC). The process of breeding and evaluating the cultivars took place over a period of 18 years (Labuschagne, personal communication, 2018). Currently Culdevco owns the breeding rights and they supply Marlo Farms in Mookgophong, who are the largest producers of low-chill apples in South Africa. The yields and prices of the cultivars were validated by communication with pome fruit technicians, breeders and producers.

Table 4.5 Crop variety distribution for production system 2

Crop	Variety	Established (ha)	% of Total established area (52 ha)
Apples	Panorama Golden	3	6%
	Royal Beaut	5	10%
	Granny Smith	2	4%
Low-chill Apples	Afri-Blush	3,5	7%
	Afri-Glo	3,5	7%
Pears	Forelle	10	19%
	Bon Chretien	3	6%
	Packhams	5	10%
	Early Bon Chretien	3	6%
	Abate Fetel	2	4%
	Rosemarie	2	4%
	Other	2	4%
Peaches	Keisie	3	6%
	Oom Sarel	2	4%
Nectarines	N/A	3	6%
Total		**52**	**100%**

Table 4.6 gives information on the pack-out percentages and prices of the low-chill apple cultivars. Conservative values were used for the yields of the low-chill apples. This is due to the uncertainty around the actual performance of the apples. To account for this, various scenarios are conducted at the end of the chapter to determine the profitability of the apples should the yields and prices differ.

Currently only a small percentage of the apples are exported as the volumes are too low and there is a risk factor involved in exporting (Meiring, personal communication, 2018). However, as volumes are expected to increase, producers will increasingly export to neighbouring countries as the local market will become saturated (De Wet, personal communication, 2018).

A major benefit of producing low-chill apples is that they can be harvested one to two months earlier (depending on location) before the first standard cultivars enter the market. Producers in the Warm Bokkeveld can potentially harvest low-chill apples from the first week in January. At this time there are no fresh apples in the market and consumers might be willing to pay a premium for the fresh low-chill varieties. Table 4.6 indicates the prices paid to producers for the various categories. These prices are paid to the producer after CFG deducts packaging, storage and distribution costs. As there are no other apples in the market, the cost of storage would be considerably lower as the time spent from storage to distribution is shorter than that of standard cultivars (Odendaal, personal communication, 2018).

Table 4.6 Low-chill varieties pack-out percentages and prices.

Low-chill apples	Pack-out %					Expected price (R/ton)			
	Ton/ha	Class 1 Export	Class 1 Local	Class 2	Class 3	Class 1 Export	Class 1 Local	Class 2	Class 3
Afri-Glo	60	20%	70%	5%	5%	R 7 000	R 6 000	R 500	R 500
Afri-Blush	60	20%	70%	5%	5%	R 7 000	R 6 000	R 500	R 500

Table 4.7 highlights the gross margin/ha and the total gross margin of the two low-chill cultivars. From Table 4.7 it is clear that the low-chill apples have high gross margins. The only crop variety with a higher gross margin per hectare is Panorama Golden. The key factor contributing to their high gross margins is the pack-out percentage. In Table 4.6 we can see that a large percentage of the harvested apples are classified under Class 1 local, and this category receives R 6 000/ton, which is the highest for this category of all apple cultivars in the model.

Table 4.7 Low-chill apples gross margins

Crop	Variety	Established (ha)	Gross margin/ha	Total gross margin
Apples	Afri-Blush	3,5	R 257 344	R 900 705
	Afri-Glo	3,5	R 257 344	R 900 705

4.3.1 Capital requirement

The capital requirement discussed in Paragraph 4.2.1 is the financial investment that is required to purchase the farm inventory that is necessary to start and operate the farming enterprise. The farm inventory consists of land, fixed improvements, vehicles, machinery and implements. The fixed improvements, vehicles, machinery and implements required to run the farming system is exactly the same for both production alternatives. However, the value of land for pome fruit and stone fruit differ by a margin of R 100 000/ha; this means that the cost of land is more expensive for production system 2. The total capital required for production system 2 is R 31 350 240, which is a R 200 000 increase from production system 1. This increase in capital requirement has an impact on the IRR and the NPV. However, low-chill apples are more profitable than the varieties they replaced so this offsets the impact on the IRR and NPV.

Table 4.8 below indicates the land distribution for production system 2. As previously mentioned, all aspects of the farming inventory remain the same for both production systems, except for land. The new land distribution indicates that the cultivated area is split up into 17 ha of apples, 27 ha of pears and 8 ha of stone fruit.

Table 4.8 Land distribution for production system 2

Land distribution	**%**	**Ha**	**Value**
Own land	100%	500	27 140 000
Rented land	0%	0	
Water availability	450000	m^3	1 600 000
Water requirement per ha	8000	$m^{3/ha/year}$	
Ha under production	56		
Land Use	**Number ha**	**R/ha**	**Value**
Arable	200		
Irrigation Land	148	30000	4 440 000
Cultivated Land	52		
Pome Fruit	44	450000	18 900 000
Stone Fruit	8	350000	3 500 000
Grazing	4	150000	600 000
Non-arable (roads, dams, etc.)	20	5000	100 000
Crop distribution	**Apples**	**Pears**	**Stone Fruit**
Ha	17	27	8

4.3.2 Profitability

The criteria for profitability was explained in Paragraph 4.2.1.5; the two criteria in the study used to measure profitability are IRR and NPV. For production alternative 2, the area of Forelle pears and Keisie peaches were reduced. They were replaced with low-chill apple cultivars, Afri-Blush and Afri-Glo. Changing the crop distribution has a direct influence on the profitability of the whole farm. Afri-Blush and Afri-Glo have higher gross margins than Forelle and Keisie, hence the expected result is that production alternative 2 will be more profitable than production alternative 1.

Table 4.9 indicates the results of the profitability calculation for production alternative 2. The IRR of the production system is calculated to be 7,13% and the NPV is equal to R 21 211 422. To ensure that the production alternatives' NPVs can be compared, the discount rate for both cases have to be the same. The NPV indicates the discounted value of all the future cash flows generated in alternative 2's farming system. The capital budget for production system 2 is illustrated in Annexure C.

Table 4.9 Profitability criteria for production system 2

Production system 2	Discount rate	Internal rate of return (IRR)	Net present value (NPV)
Typical farm with low-chill apples included	2,40%	7,13%	R 21 211 422

4.4 Profitability comparison

Table 4.10 summarises the main results of the two alternative production systems. Production system 2 is the most profitable according to the IRR and NPV calculations. In the table we can see the capital requirement for production system 2 is slightly more than production system 1. This is due to the change in crop distribution. In the second production alternative, 44 ha of pome fruit and 8 ha of stone fruit is cultivated. This is compared to the first production alternative, where 42 ha of pome fruit and 10 ha of stone fruit is cultivated.

Table 4.10 Profitability criteria for both production systems

Production system	Discount rate	Capital requirement	Internal rate of return (IRR)	Net present value (NPV)
System 1	2,40%	R 31 150 239,74	3,64%	R 5 372 694,52
System 2	2,40%	R 31 350 239,74	7,13%	R 21 211 421,71

Alternative 2 is considerably more profitable than alternative 1. Following is a list of factors that contribute to this result:

- Alternative 1: large percentage of area planted under Forelle pears, which has a low gross margin.
- Alternative 1: peaches also have low margins as crop is used for canning.
- Alternative 2: less area of Forelle pears and Keisie peaches cultivated.
- Alternative 2: low-chill apples receive high Class 1 prices due to early harvesting period.

From the financial analysis that was conducted in the study it is clear that producers stand to gain from the inclusion of low-chill apples in their farming systems. Table 4.11 below highlights the gross margins of the low-chill apples and the cultivars they replaced. From the table we can clearly see the large difference in the gross margins generated by the respective crops. The total gross margin foregone in production system 2 is R 827 255. However, the total gross margin generated by the low-chill apples is R 1 801 410. This is almost a R 1 000 000 increase in total gross margin. This results in a higher whole-farm gross margin each year for production system 2, and hence a higher profitability.

Table 4.11 Gross margin of crops included and excluded in production system 2

Crop	Variety	Established (ha)	Gross margin/ha	Total gross margin
Apples	Afri-Blush	3,5	R 257 344	R 900 705
	Afri-Glo	3,5	R 257 344	R 900 705
Crop	**Variety**	**Replaced**	**Gross margin/ha**	**Total Gross Margin**
Pears	Forelle	5	R 140 588	R 702 942
Peaches	Keisie	2	R 62 156	R 124 313

4.5 Scenarios

The multi-period whole-farm budget model was developed to determine the profitability of various farming systems in the Warm Bokkeveld. To construct the typical farm various assumptions and parameters had to be identified and validated by a group of experts. The typical farm represents the mode of farms and not the average of the farms in a homogenous region. In the model, the assumptions were based on producers that are well-experienced and conduct best farming practices to achieve maximum yield levels. Altering assumptions enable the model to simulate real-world occurrences that influence the whole-farms profitability. These occurrences include external factors such as climatic conditions that can affect yields or market fluctuations that can affect price levels. The actual performance of the low-chill apples are unknown, therefore the alterations could possibly give a completely different indication of the profitability of the apples.

These alterations are done through scenarios, in which a specific change is made to existing assumptions to determine the impact of various “what if” situations (Institute for Futures Research, 2013). To assess the impact of altering assumptions, a scenario should be created where only one variable is changed and the rest of the assumptions remain constant (Van der Heijden, 1996). This is known as a sensitivity analysis and is extremely effective in illustrating the level of impact various assumptions have on the whole-farms profitability. The results of a sensitivity analysis can also guide producers to determine which farming system is best as different assumptions can influence the alternative production systems differently. For example, production alternative 2’s farming system is the most profitable, however should the assumptions on the prices or yields of low-chill apples drop drastically, alternative 1 could become more profitable.

In the study, the assumptions regarding the yields and prices of low-chill apples were discussed and validated through discussions with experts. The most important assumption regarding these apples is the time of harvest, which influences the price level. If the apples are harvested the same time as standard cultivars, the price paid for low-chill apples will decrease considerably, as they have to compete with other fresh apples that have better storage capability. Hence, scenarios will be run to determine the profitability of low-chill apples should the assumptions deviate.

4.5.1 Change in Class 1 local price for low-chill apples

In production alternative 2's crop distribution, low-chill apples constitute around 15% of the total cultivated area. A change in the price of the apples can have an impact on the whole-farm's profitability. Producers, however have no influence on the external economic factors that determine the price for these apples. To determine the impact of price changes, a sensitivity analysis is conducted where the price levels are altered and the resulting impact on the whole farm's profitability is recorded and analysed.

The first scenario is an increase in the price of Class 1 low-chill apples. The current price for Class 1 local apples is R 6 000/ton. The impact of price increases on the farm's profitability is recorded in Table 4.12. In the scenario, the price level is increased three times in increments of R 500/ton. As the scenario is only applicable to low-chill apple's assumptions, production alternative 1's profitability is not influenced. As can be expected, price increases have a positive influence on the whole-farm's profitability. Table 4.12 highlights the IRR and the relative percentage change of each price increase. Should the price of low-chill apples increase by R 500, the IRR of production alternative 2 will be twice as high as the IRR of production alternative 1.

Table 4.12 Increase in low-chill apple prices

Production system	Current production systems		Scenario: Increase in low-chill apple Class 1 local prices by:					
			R 500		R 1 000		R 1 500	
	IRR	NPV	IRR	Relative change	IRR	Relative change	IRR	Relative change
System 1	3,64%	R 5 372 694,52	N/A	N/A	N/A	N/A	N/A	N/A
System 2	7,13%	R 21 211 421,71	7,68%	7,71%	8,24%	15,57%	8,79%	23,28%

A scenario where the price of low-chill apples decreases is also given. The results of this scenario allow us to determine what price change has a bigger influence on the whole-farm's profitability.

Table 4.13 indicates the results of the price decrease scenario. In the scenario, the current price for Class 1 local low-chill apples (R 6 000) is decreased three times in increments of R 500/ton and then the respective IRRs are calculated. To ensure the sensitivity analysis is accurate, the same procedure has to be conducted when increasing and decreasing the price. Alternative 1 is not affected by the price changes as it does not have any low-chill apples in its crop distribution.

Reducing the price of low-chill apples resulted in a decrease of alternative 2's whole-farm profitability. This affect is expected as the whole-farm's gross margin for each year decreases. From Table 4.12 and 4.13 we can deduce which scenario has a larger impact on the whole-farm's profitability. By comparing the relative changes in IRRs, we can see that when prices are increased the corresponding increase in the farms IRR is larger than when prices are decreased. Therefore, price increases have a larger impact on the farms profitability.

If price levels drop by R 1 500, which brings it to R 4 500/ton, the whole-farm profitability of production system 2 is still larger than that of production system 1. At this price, the IRR of production system 2 is 5,49%, whereas the IRR of production system 1 is 3,64%. The price of Class 1 local low-chill apples has to drop to R 2700/ton for production system 1 to have a slightly higher IRR than production system 2.

Table 4.13 Decrease in low-chill apple prices

Production system	Current production systems		Scenario: Decrease in low-chill apple Class 1 local prices by:					
			R 500		R 1 000		R 1 500	
	IRR	NPV	IRR	Relative change	IRR	Relative change	IRR	Relative change
System 1	3,64%	R 5 372 694,52	N/A	N/A	N/A	N/A	N/A	N/A
System 2	7,13%	R 21 211 421,71	6,59%	-7,57%	6,04%	-15,29%	5,49%	-23,00%

4.5.2 Change in yields of low-chill apples

The total amount of apples than can be harvested at full-bearing capacity depends on two crucial factors. The first is the genetics of the variety and the second is the farming expertise of the producer. The first factor cannot be influenced by the producer. However, the second factor is directly related to the experience of the farmer. For the purpose of this study, it was assumed that the producer on the typical farm is experienced and able to achieve maximum yields.

When identifying and validating the expected yield levels of the low-chill apples, conservative values were used. In the model, the total yield at full-bearing capacity for Afri-Blush and Afri-Glo is 60 ton/ha. Currently low-chill apples are being farmed on a commercial scale in Mookgophong. The performance of the apples are extraordinary and they are expected to reach yields above 80 ton/ha from the fifth year of production (Meiring, personal communication, 2018). However, these are just estimates and to provide the concept of a typical farm, conservative yields are included.

To determine the impact of the yield on the whole-farm's profitability, two scenarios are investigated where in one scenario the yields are increased and in the second scenario the yields are decreased. The purpose of these scenarios is to determine how production alternative 2's farming system will compare with production alternative 1's farming system, if the yields are altered. Specifically attention should be given to the scenario where the yields are decreased, as the two farming systems profitability's will be more comparable. Table

4.14 shows the results of the scenario, where the yields of low-chill apples are increased. The yields are increased three times in increments of 5 ton/ha and the respective IRRs are calculated. From Table 4.14 it is clear that an increase in yields has a larger impact on the whole-farm's profitability when compared with a price increase. The yield increase only has an impact on production system 2's profitability, as production system 1 does not have low -chill apples in its crop distribution.

According to Table 4.14, if the yields are increased with 10 ha (70 ton/ha) the IRR of production alternative 2 is twice as large as production alternative 1's. Further studies have to be conducted to determine if these yield levels are in fact possible.

Table 4.14 IRR in response to increase in low-chill apple yields

Production system	Current production systems		Scenario: Increase in low-chill apple yields by:					
			5t		10t		15t	
	IRR	NPV	IRR	Relative change	IRR	Relative change	IRR	Relative change
System 1	3,64%	R 5 372 695	N/A	N/A	N/A	N/A	N/A	N/A
System 2	7,13%	R 21 211 422	7,87%	10,38%	8,62%	20,90%	9,36%	31,28%

Table 4.15 shows the impact of a decrease in the yields of low-chill apples on the whole-farm profitability of production alternative 2's farming system. As found in the price altering scenarios, an increase in the yields have a greater effect on the IRR than a decrease in yields. Even when the yield is decreased by 15 ton/ha, production alternative 2 remains more profitable than production alternative 1. At this level, low-chill cultivars only reach 45 ton/ha, which is considerably lower than standard apple and pear cultivars. For production alternative 1 to be more profitable than production alternative 2, the total yield has to drop to 30 ton/ha, which is a 50% drop from its current level. It is highly unlikely that this would be the case and it further emphasizes that production alternative 2 is considerably more profitable.

Table 4.15 IRR in response to decrease in low-chill apple yields

Production system	Current production systems		Scenario: Decrease in low-chill apple yields by:					
			5		10		15	
	IRR	NPV	IRR	Relative change	IRR	Relative change	IRR	Relative change
System 1	3,64%	R 5 372 694,52	N/A	N/A	N/A	N/A	N/A	N/A
System 2	7,13%	R 21 211 421,71	6,40%	-10,24%	5,66%	-20,62%	4,93%	-30,86%

4.6 Conclusions

The multi-period whole-farm budgeting model that was constructed in Chapter three was used to determine the profitability of two alternative production systems of a typical farm in the Warm Bokkeveld. The two alternative production systems are based on the same farm, but each had a different crop distribution. The purpose of the model was to determine which farming system is the most profitable based on their respective IRRs and NPVs.

The farm system is inherently complex and therefore a systems approach was applied in constructing a whole-farm, multi-period budget model to simulate alternative systems. Each component influenced the profitability and was highlighted and discussed. For the first alternative system the capital requirement was R 31 150 240. This includes land, fixed improvements, vehicles, machinery and implements. This component directly influences the profitability of the enterprise as it forms the baseline for the calculation of the IRR and the NPV. Production alternative 1 returned an expected IRR of 3,64% and a NPV of R 5 372 694,52. The IRR value indicates the percentage growth of the capital investment made for the first production system. The NPV shows the discounted value of all the future cash flows that are generated from this farming system. If the NPV is positive, it means the farming system will generate a profit.

In production system 2, five hectares of Forelle pears and two hectares of Keisie peaches were substituted by two low-chill apple cultivars; three and a half hectares of Afri-Blush and Afri-Glo. The capital requirement for alternative 2 is slightly higher at R 31 350 240 as the land for pome fruit is more valuable than land used for stone fruit cultivation. The profitability criteria for production system 2 indicates that it is more profitable than production system 1 as it has an IRR of 7,13% and a NPV of R 21 211 421,71. The reason for the higher profitability of production system 2 is solely due to the crop distribution. Afri-Blush and Afri-Glo apples generate higher gross margins than Forelle pears and Keisie peaches. The assumptions for the yield and production of low-chill apples were identified and validated through communication with experts. However, the actual performance of these apples is uncertain as they are currently in the early stages of commercial production.

A sensitivity analysis was conducted to determine the variance in profitability of production system 2 should the assumptions of low-chill apples be altered. The sensitivity analysis was conducted by running two scenarios. In the first scenario, the price level for class 1, local low-chill apples was changed and then the resulting influence on the IRR was calculated. The price levels were increased and decreased three times in increments of R 500. In the second scenario the yields of the low-chill apples at full-bearing capacity were altered. The yields were increased and decreased three times in increments of 5 ton/ha. From the sensitivity analysis, it was concluded that production system 2 remains more profitable than production system 1. In each case where the price and yield levels were decreased, the IRR of alternative 2's production system remained higher than alternative 1's production system.

The results of the model indicate that a farming system that includes low-chill apples in its crop distribution is more profitable. It is important to note that the study was done to test the profitability of low-chill apples on a farm-level. From the results, cultivating low-chill apples can provide producers with many potential financial benefits. On the farm level, low-chill apples are more profitable than most of the crop varieties found on the typical farm. However, it is also important to note that this was not a marketing study and the goal was not to identify potential markets. Therefore, the study does not suggest that producers should replace current varieties with low-chill apples, before conducting significant market research.

From the data gathered by CFG, Forelle pears is the variety that is planted on the largest scale in the Warm Bokkeveld, even though it generates one of the lowest gross margins. Large-scale cultivation could be due to the institutional structure surrounding the variety. Another possible explanation is that it is a more stable variety than other crop varieties. For example, the prices for exporting apples are high, but the market for apple exports could be capped and above a certain amount of apple exports, prices drop drastically. Hence, apples are more price sensitive and riskier and Forelle pears are viewed as a better option.

The following chapter is the conclusion of the study. In this chapter, the most important findings of each chapter will be discussed. A short summary of the study will be given which gives the reader an understanding of the entire process from start to finish. At the end of the chapter recommendations will be given based on the potential of future studies and how potential shortcomings can be avoided.

Chapter 5: Conclusions

5.1 Conclusion

Developing countries such as South Africa rely heavily on their agricultural industry to ensure continued economic growth. Agriculture only contributes 2,6% to total GDP, but it is still an important sector that has spill over effects into the rest of the economy. South Africa's agricultural sector is also a key employer of the labour force (5,47%) and many rural communities depend on agriculture to uphold their way of life.

The deciduous fruit industry is one of South Africa's most important industries and an earner of trade income. Deciduous fruit production is limited to areas that accumulate enough cold units throughout the winter months. Most of the deciduous fruit production occurs in the Western Cape Province. The Western Cape has a typical Mediterranean climate. The Warm and Koue Bokkeveld are regions in the Western Cape that contribute greatly to the overall deciduous fruit industry. Producers in the region focus on the production of pome and stone fruit. The quality and yield of fruit in the Koue Bokkeveld is better as it is at a higher altitude and experiences more cold units, especially in the case of apple production. The Warm Bokkeveld faces a phenomenon called delayed foliation, which results in poorer quality fruit and lower yields. As a result, producers in the region are considered to be less profitable.

The breeding of low-chill apples was done to overcome the problem of delayed foliation. This could potentially expand the regions where apples can be produced. These apple cultivars could be cultivated in less favourable areas. In South Africa, the production of low-chill apples has only recently taken place on a commercial scale in the Limpopo province at Mookgophong. The apples show good potential, but the actual performance will only be clear in coming years.

The Warm Bokkeveld is a region that could potentially introduce the cultivation of low-chill apples. This will help producers to overcome the problem of delayed foliation. The plant breeders also indicated that the harvesting of low-chill apples in the Warm Bokkeveld would commence in the first week of January. Producers could then potentially be in the market at least one month before the rest of the Western Capes apples are harvested. These apples would be the earliest fresh apples on the market and consumers might be willing to pay a premium for them. However, these apples do not have a good storage capability and they should be sold before they have to compete with standard cultivars. To determine if the apples could be successfully implemented in the Warm Bokkeveld, a financial analysis was conducted.

Farming systems are extremely complex in nature and consist of various components that are interrelated through relationships. The degree of complexity is determined by the nature of the farming enterprise. To successfully model the financial performance of low-chill apples in the Warm Bokkeveld, a systems approach was applied. The systems approach gives a holistic view of a farming system and does not isolate components. To determine if farming systems that include low-chill apples are more profitable than current farming systems the profitability of farms in the Warm Bokkeveld would first have to be measured.

A typical farm for the Warm Bokkeveld was identified and a whole-farm model constructed to serve as a basis for comparison. Experts from various disciplines were used to establish the assumptions and parameters of the structure of such a typical farm. The various disciplines included agricultural economists, pome fruit technicians, and producers. The typical farm was incorporated into a whole-farm, multi-period budgeting model. The budget was constructed over a period of 25-years. The budgeting model simulated the performance of a typical farm in the Warm Bokkeveld. The profitability of the typical farm was measured by calculating the IRR and NPV. The dynamics of the model allow for it to be altered to simulate various farming system. In the study, the typical farm was taken as it is but the crop distribution was altered to incorporate low-chill apples. The assumptions on low-chill apples were validated through expert discussions with pome fruit technicians, breeders and producers. These assumptions were incorporated into the whole-farm, multi-period budgeting model and a second simulation was incorporated. The IRR and NPV of the production systems were recorded and used to compare the profitability of the two production systems.

The results of the two alternative production systems indicate that the second production system, including low-chill apples in place of pears and peaches, is more profitable. This was measured in terms of the profitability criteria, IRR and NPV. This means that producers can stand to improve their profitability by incorporating low-chill apples into their farming systems.

There is no current research on the financial performance of low-chill apples. A sensitivity analysis was conducted to determine if production alternative 2 would remain more profitable if the assumptions of low-chill apples are changed. The sensitivity analysis was conducted by running various scenarios and then calculating the respective IRRs. The first scenario proposed a change in the price levels for low-chill apples. The second scenario proposed a change in the yields of low-chill apples harvested at full-bearing capacity. In each scenario, six price or yield alterations were made and the respective IRRs calculated.

With regards to the price changes, the price for Class 1, local low-chill apples (R 6000/ton) was increased three times in increments of R 500/ton and subsequently decreased three times with R 500/ton. In each price alteration, the IRR of production alternative 2 was still higher than production alternative 1. For production alternative 1 to be more profitable, the price for Class 1 local apples would have to drop with R 3 300/ton, which is a larger than a 50% drop from the original price level. A similar result was found with the yield alterations. The current yield level of 60 ton/ha was increased three times in increments of 5 ton/ha and then also decreased three times with 5 ton/ha. In each alteration the IRR of production system 2 was still higher than production system 1's. For production system 1 to have a higher IRR, the current yield level has to drop to 30 ton/ha, which is a 50% decrease from the current yield level.

The use of whole-farm, multi-period budgeting models to assess the impact of including low-chill apples in a Warm Bokkeveld production system was successful in highlighting the effects on the profitability of the alternative production systems. The use of expert knowledge and industry data was sufficient to obtain and validate data for research purposes.

5.2 Summary

The importance of the deciduous fruit industry in the Western Cape was illustrated. A problem with deciduous fruit production is the phenomenon called delayed foliation. This occurs when trees do not accumulate enough cold units in the winter and it influences plant growth negatively. This problem exists in the Warm Bokkeveld and has a negative impact on the quality and yield of the fruit, especially apples, which influences the overall profitability of the enterprise. Low-chill apples were identified as a potential crop that could be cultivated in this region to overcome the issue of delayed foliation. A concern with the cultivation of these apples is that there is a lack of research on the financial aspects of cultivating them. The research question for the study was, "what is the financial feasibility of cultivating low-chill apples in the Warm Bokkeveld?" To answer the research question, a number of objectives were set out. These objectives involved assessing the current financial performance of farms in the Warm Bokkeveld, assessing the performance of these apples in Limpopo and assessing the incorporation of low-chill apples into a farming system in the Warm Bokkeveld.

Chapter two involved the literature review. In this chapter attention was focused on similar studies to determine the most effective way to answer the research question. The purpose of the development of low-chill apples was discussed and the Warm Bokkeveld was introduced as a potential area where it can be cultivated. Including low-chill apples could result in increased profitability for these producers. Earlier harvesting periods ensure low-chill apples are the only fresh apples on the market resulting in price premiums for producers. However, the uncertainty of earlier harvesting periods and a lack of storage capability are the two challenges that raise concerns for producers.

Farming systems are extremely complex in nature and a systems approach is required to represent the interrelatedness of the various components. The purpose of the study is to determine the financial implications of incorporating low-chill apples into a farming system in the Warm Bokkeveld. Therefore, to capture the interrelatedness of the components, a holistic view of the farming system should be taken. To do this, a whole-farm, multi-period budgeting model was constructed to simulate the farming systems over a 25-year period. A typical farm had to be established to serve as a basis for comparison. This study tested the impact by comparing two alternative production systems; the first production system models the typical farm in the Warm Bokkeveld and assesses the profitability of current producers. The second production system includes low-chill apples to determine if it is financially viable and if producers can stand to gain from incorporating these cultivars.

Chapter three dealt with in-depth explanations as to how the typical farm and budgeting model was developed. The economic importance of the Warm Bokkeveld was highlighted and the construction of the typical farm was discussed. A typical farm has to be representative of farms in a relatively homogenous area. Therefore, the parameters and assumptions regarding a typical farm were identified and validated through discussions with CFG and multiple producers in the Warm Bokkeveld. The parameters and assumptions included the physical dimensions of the farm, crop yields, prices, costs of inputs and farm inventory. To include low-chill apples in the model, discussions with various experts had to be held. The assumptions regarding low-chill apples were discussed and validated by pome fruit technicians and producers currently cultivating the apples.

After the typical farm was identified and constructed, it had to be incorporated into a whole-farm budgeting model. The budgeting model was constructed in an excel spreadsheet. The spreadsheet makes it possible to capture the interrelatedness of the various components. The components are built into different sheets throughout the model and the dynamics of the model allows changes in assumptions to immediately influence the entire model's outcome. The sophistication of the budgeting model lies in the number of variables and the relationships between the variables that can be modelled. To calculate the profitability of the typical farm, the gross margin of each crop variety is calculated. The gross margins are added up to determine the whole-farm's gross margin, the respective fixed costs, factor costs and capital requirement is deducted and the result is the net annual flow for the year. The calculations are conducted over a period of 25 years and from the multiple net annual flows the IRR and NPV of the farming system can be calculated.

The calculations explained above are presented in Chapter four. The first production system's calculations were done to assess the current financial performance of a typical farm in the Warm Bokkeveld. The financial performance was assessed based on the profitability criteria, namely the IRR and NPV of the farming system. The results were calculated and recorded. Alterations were made to the typical farm's crop distribution to simulate production system 2. A section of pear and peach cultivars were replaced with low-chill apples and the apple's assumptions were included in the model. The changes were immediately replicated throughout the model and the IRR and NPV of production system 2 was recorded. From the results, production system 2 is considerably more profitable than production system 1. The IRR and NPV for production system 1 are 3,64% and R 5 372 695 respectively. The IRR and NPV for production system 2 are 7,13% and R 21 211 422 respectively. To test the variance in the profitability of production system 2, a sensitivity analysis was conducted. This was done by running scenarios that change the assumptions of the low-chill apples. The scenarios replicate external factors that can influence the success of the apples. The scenarios included price and yield changes for low-chill apples. The price and yield were increased and decreased three times and the respective IRRs were calculated. As can be expected, the price and yield-increase scenarios further increased the profitability of production system 2 relative to production system 1. The price decrease scenarios generated the following IRRs: 6,59%; 6,04% and 5,49%. The yield decrease scenarios resulted in the following IRRs: 6,40%; 5,66% and 4,93%. The result of the sensitivity analysis indicates that production system 2 is still more profitable regardless of the various assumption alterations.

5.3 Recommendations

The main purpose of the study was to determine the financial feasibility of low-chill apple cultivars in the Warm Bokkeveld. The need for this originated from the problem producers face with delayed foliation, which is as a result of insufficient cold units. A financial analysis was conducted to determine the implication of including low-chill apples in a producer's farming system. A whole-farm, multi-period budget was constructed with the input of experts from different disciplines. The budgeting model evaluated the financial performance of current farms in the Warm Bokkeveld. The model was then used to simulate the financial performance of these farms if they incorporate low-chill apples in their farming systems. Many critical aspects of low-chill apples are based on assumptions that have not been proven. Therefore, there is a need for much greater understanding of these apple cultivars, especially in the Warm Bokkeveld.

The study made use of data from the performance of low-chill apples in Mookgophong. This region accumulates much fewer cold units than the Warm Bokkeveld. The apples have shown much promise and they are only in their third year of production. Therefore, the yield predictions were made based on the knowledge of pome fruit technicians, breeders and the producers. Further studies should be conducted in the following years to determine if the apples are in fact capable of reaching those yields at full-bearing capacity. Studies should also be conducted where the apples are cultivated in the Warm Bokkeveld to determine if they can grow in the region.

Low-chill apples have the benefit of entering the market with no competition from standard apple cultivars. This ensures producers can receive a premium price for these freshly harvested apples. The high prices received for low-chill apples were a strong contributor to their profitability. These high prices were established with the assumption that the apples are harvested in the first week of January. Further studies should be conducted to determine if the apples can truly be harvested at this time as this will greatly influence their profitability.

The study focused on the farm-level application of low-chill apples. No research was undertaken to determine if there is a market for these apples. If the market demand is uncertain, producers might not be willing to replace Forelle pears and Keisie peaches that have a better market certainty. Therefore, further studies could investigate the demand for low-chill apples and the likeliness of producers including low-chill apples in their farming systems.

The gross production value generated from low-chill apples was solely attributed to pack-outs into various classes. Further studies could investigate the potential for other income sources from low-chill apples, such as for juicing or canning. This can to an extent diversify the income source; should external climatic conditions influence the quality of the fruit, producers could stand to generate higher gross margins from juicing, rather than class 3 quality apples.

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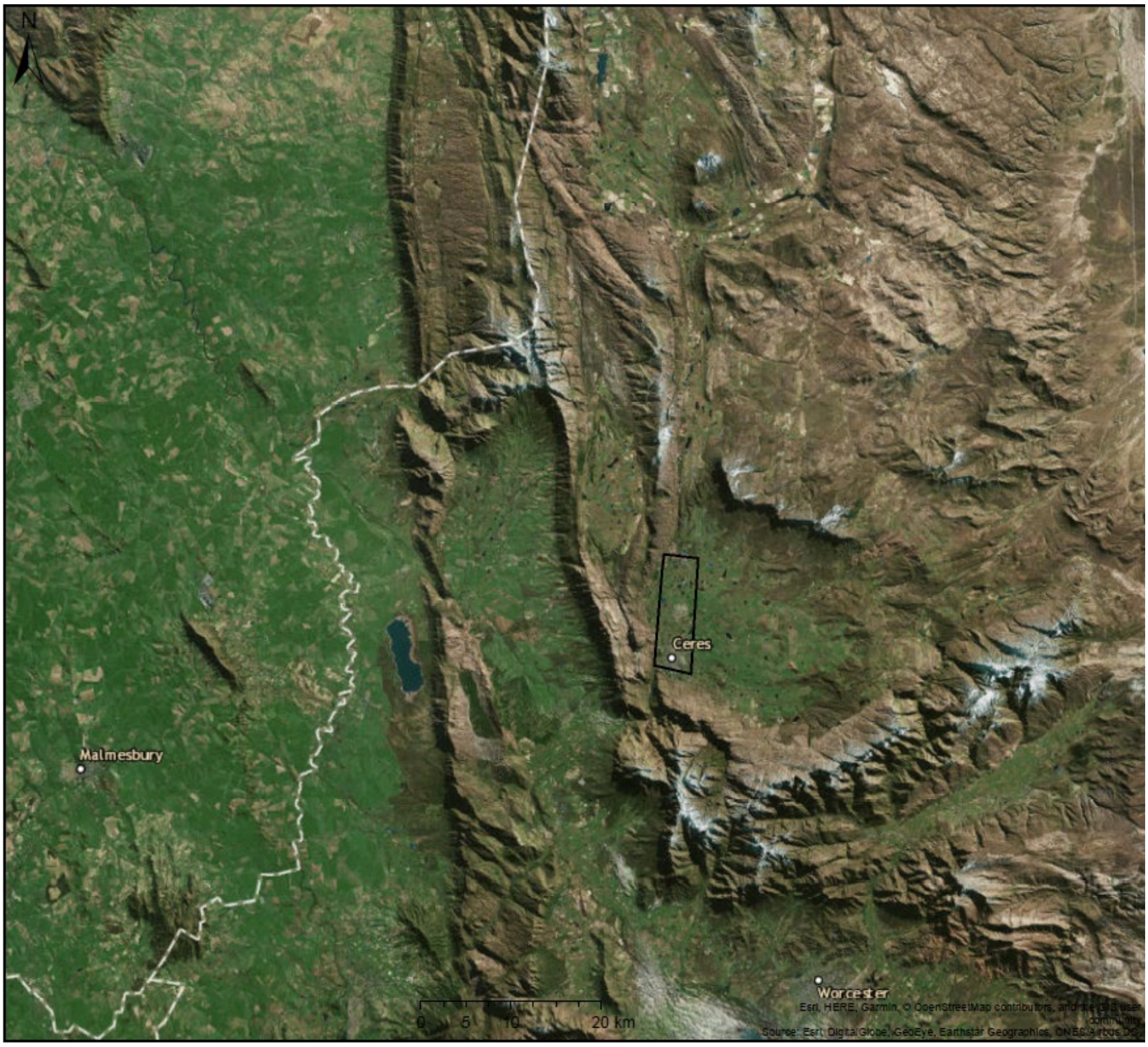
ADDENDA

Annexure A: Map of the Warm Bokkeveld, including Ceres and Prince Alfred Hamlet



Annexure B: Capital budget for production system 1

Capital Budget												
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross margin: Apples												
Panorama Golden	603939	641337	720070	777151	777151	777151	777151	777151	777151	338951	573657	603939
Royal Beaut	848680	952918	1031097	1031097	1031097	409621	759397	848680	952918	1031097	1031097	1031097
Granny Smith	192356	332266	370830	416326	450449	450449	450449	450449	450449	450449	192356	332266
Gross Margin: Nectarines & Peaches												
Keisie Inmaak	310783	310783	310783	310783	310783	310783	310783	310783	310783	310783	310783	310783
Nectarines	186598	246096	290720	290720	290720	290720	290720	290720	290720	290720	290720	290720
Oom Sarel	102689	102689	102689	102689	102689	102689	102689	102689	102689	102689	102689	-239617
Gross margin: Pears												
Forelle	1637435	1739212	1953481	2108826	2108826	2108826	2108826	2108826	2108826	2108826	2108826	2108826
Bon Chretien	302286	321107	360730	389457	389457	389457	389457	63223	284954	302286	321107	360730
Packhams	568334	603631	677942	731817	731817	167414	536965	568334	603631	677942	731817	731817
Early Bon Chretien	384279	405584	430696	483562	521890	521890	521890	521890	521890	521890	521890	521890
Abate Fetel	153570	180672	212088	278226	326177	326177	326177	326177	326177	326177	326177	326177
Rosemarie	359927	359927	359927	359927	359927	359927	359927	359927	359927	359927	-125196	170445
Other	333505	359927	359927	359927	359927	359927	117365	265186	279750	297061	333505	359927
Total farm gross margin	**5984380**	**6556151**	**7180979**	**7640508**	**7760908**	**6575029**	**7051796**	**6994034**	**7369864**	**7118797**	**6719428**	**6909001**
Fixed Costs												
Labour	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408
Water rights	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996
Bank Costs	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Electricity	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000
Auditers fee	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
Communication	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000
Maintenance fixed improvements	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000
Fuel	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000
Maintenance & repairs	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265
Other												
Total fixed costs (b)	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**
Factor costs												
Hired management	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000
Rented land												
Payments	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18
Total factor costs ©	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**
Capital items												
Land	**26940000**				0,86484							

13	14	15	16	17	18	19	20	21	22	23	24	25
641337	281869	573657	603939	641337	720070	777151	338951	573657	603939	641337	281869	573657
409621	759397	848680	952918	409621	759397	848680	952918	1031097	1031097	1031097	409621	759397
370830	416326	450449	192356	332266	370830	416326	450449	192356	332266	370830	416326	450449
310783	310783	310783	310783	-912881	-35106	85334	214162	310783	310783	310783	310783	310783
290720	-128504	134828	186598	246096	290720	290720	290720	290720	290720	290720	-128504	134828
40204	65167	86608	102689	102689	102689	102689	-239617	40204	65167	86608	102689	102689
2108826	437272	1545927	1637435	1739212	281927	1545927	-34120	1176313	1482090	1739212	281927	1545927
389457	63223	284954	302286	321107	360730	389457	63223	284954	302286	321107	34497	284954
731817	731817	731817	731817	731817	167414	536965	3931	408780	514459	603631	113538	536965
162548	384279	46242	293085	367256	430696	124220	384279	405584	430696	483562	521890	162548
326177	326177	326177	326177	326177	326177	326177	-142071	153570	180672	212088	278226	-142071
199572	234194	307083	359927	359927	-125196	170445	199572	234194	307083	359927	359927	359927
359927	359927	359927	359927	359927	359927	359927	-125196	170445	-42989	139454	226906	297061
6341819	**4241929**	**6007132**	**6359936**	**5024552**	**4010273**	**5974017**	**2357201**	**5272659**	**5808270**	**6590357**	**3209695**	**5377114**
1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408
429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996
24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000
144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000
780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000
408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000
379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265
4098669	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**
288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000
636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18	636808,18
924808	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**	**924808**

Fixed Improvements													
House		600 000											
Employee housing													
Manager		300 000											
Workers housing		800 000											
Farm buildings and installations													
Storage room		225 000											
Chemical storage room		33 333											
Pump house		3 333											
Other fixed improvements		-											
Total fixed improvements		**1 961 667**											
Moveable assets													
Vehicles and machinery													
Two-wheeler		29 844	0	0	0	0	0	0	0	0	0	41967,9	0
Pickup truck													
LAA 2.5 Diesel Double Cab		52 379	0	0	0	127409,4	0	0	0	0	0	0	0
LAA 2.5 Diesel Double Cab		52 379	0	0	0	127409,4	0	0	0	0	0	0	0
Truck													
8t		150 797	0	0	0	0	0	0	0	0	295037,1	0	0
14t double axle		105 139	0	0	0	0	0	291154,5	0	0	0	0	0
Other operating vehicles													
Tractors													
Orchard		209 035	0	0	0	0	0	0	0	0	0	0	0
Orchard		130 150	0	0	0	0	0	0	0	0	0	231949,8	0
Orchard		169 949	0	0	0	0	0	0	0	0	0	151439,4	0
Orchard		249 309	0	0	0	0	0	0	0	0	0	0	0
Orchard		333 200	0	0	0	0	0	0	0	0	0	0	0
Orchard		333 200	0	0	0	0	0	0	0	0	0	0	0
0													
Forklift													
Forklift 3t		54 080	0	0	0	0	0	0	0	93600	0	0	0
Forklift 3t		117 800											
Total Vehicles and Machinery		**1 987 260**	**0**	**0**	**0**	**254 819**	**0**	**291 155**	**0**	**93 600**	**295 037**	**425 357**	**0**
Implements:													
Sprayer													
Towing sprayer (1) 1500l		24 479	0	0	0	67788,9	0	0	0	0	0	0	0
Towing sprayer (2) 1500l		19 238	0	53275,5	0	0	0	0	0	0	0	0	0
Turbmatic 1500l		14 799	0	0	53275,5	0	0	0	0	0	0	0	0
Three-point 400l (herbicides)		10 275	0	0	0	33028,2	0	0	0	0	0	0	0
Land preparation implements													
Plow		320	0	0	1800	0	0	0	0	0	0	0	0
Disc Plough 4 furrouw		9 800	0	0	0	0	31500	0	0	0	0	0	0
Ghrop		11 000	0	0	0	0	0	0	0	0	0	0	18000
Other													
Tip trailer 3t		52 303	0	0	0	0	0	0	0	0	0	0	0
Trailer with Brake 3t		13 797	0	0	0	0	0	0	0	0	26994,6	0	0
Bin wagons		9 120	0	0	0	0	0	0	0	0	0	0	0
Rovic Chalk distributer		24 369	0	0	0	0	0	0	0	0	0	0	0
Weedcutter 0,9m 3 blade, light duty		6 127	0	0	0	0	0	0	0	0	0	0	10026
Electrical mobile waterpump		19 200	0	0	0	0	0	0	0	0	0	0	0
Content of workshop and equipment		13 685	0	0	0	0	0	0	0	0	0	0	0
Orchard equipment (pruning scissors, ladders, bags		32 800	0	0	0	0	0	0	0	0	0	0	0
Total Implements		**261 313**	**0**	**53 276**	**55 076**	**100 817**	**31 500**	**0**	**0**	**0**	**26 995**	**0**	**28 026**
Total moveable		**2 248 573**	**0**	**53 276**	**55 076**	**355 636**	**31 500**	**291 155**	**0**	**93 600**	**322 032**	**425 357**	**28 026**
Total Capital (d)		**31 150 240**	**-**	**53 276**	**55 076**	**355 637**	**31 500**	**291 155**	**-**	**93 600**	**322 032**	**425 357**	**28 026**
Netto jaarlikse vloei (a-b-c-d)		**-30 189 337**	**1 532 674**	**2 104 226**	**2 561 955**	**2 381 795**	**1 520 052**	**1 737 164**	**1 970 557**	**2 252 787**	**1 773 288**	**1 270 594**	**1 857 498**
IRR		3,64%											
NPV	2,40%	5 372 694,52											

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	127409,4	0	0	0	0	0	0	0	0	0	0
0	0	127409,4	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	293955,3	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	259396,2	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	299880	0	0	0
0	0	0	0	0	0	0	0	0	299880	0	0	0
0	0	0	0	0	0	0	0	0	0	0	93600	0
0	**293 955**	**254 819**	**0**	**0**	**0**	**259 396**	**0**	**0**	**599 760**	**0**	**93 600**	**0**
0	0	0	0	67788,9	0	0	0	0	0	0	0	0
0	0	53275,5	0	0	0	0	0	0	0	0	0	0
0	0	0	53275,5	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	33028,2	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	64483,2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	10800	0
0	34268,4	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	27000	0	0	0	0	0	0	0	0	0	0	0
20700	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	36000	0	0	0	0	0	0	0
20 700	**61 268**	**53 276**	**117 759**	**67 789**	**36 000**	**0**	**33 028**	**0**	**0**	**0**	**10 800**	**0**
20 700	**355 224**	**308 094**	**117 759**	**67 789**	**36 000**	**259 396**	**33 028**	**0**	**599 760**	**0**	**104 400**	**0**
20 700	**355 224**	**308 094**	**117 759**	**67 789**	**36 000**	**259 396**	**33 028**	**-**	**599 760**	**-**	**104 400**	**-**
1 297 642	**-1 136 772**	**675 560**	**1 218 700**	**-66 714**	**-1 049 204**	**691 144**	**-2 699 305**	**249 182**	**185 033**	**1 566 880**	**-1 918 182**	**31 503 877**

Annexure C: Capital budget for production system 2

Capital Budget												
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross margin: Apples												
Panorama Golden	603939	641337	720070	777151	777151	777151	777151	777151	777151	338951	573657	603939
Royal Beaut	848680	952918	1031097	1031097	1031097	409621	759397	848680	952918	1031097	1031097	1031097
Granny Smith	192356	332266	370830	416326	450449	450449	450449	450449	450449	450449	192356	332266
Gross margin: Low chill Apples												
Afri-Blush	420938	688496	741699	832560	900705	900705	900705	900705	900705	900705	420938	688496
Afri-Glo	420938	688496	741699	832560	900705	900705	900705	900705	900705	900705	420938	688496
Gross Margin: Nectarines & Peaches												
Keisie Inmaak	186470	186470	186470	186470	186470	186470	186470	186470	186470	186470	186470	186470
Nectarines	186598	246096	290720	290720	290720	290720	290720	290720	290720	290720	290720	290720
Oom Sarel	102689	102689	102689	102689	102689	102689	102689	102689	102689	102689	102689	-239617
Gross margin: Pears												
Forelle	1091623	1159475	1302321	1405884	1405884	1405884	1405884	1405884	1405884	1405884	1405884	1405884
Bon Chretien	302286	321107	360730	389457	389457	389457	389457	63223	284954	302286	321107	360730
Packhams	568334	603631	677942	731817	731817	167414	536965	568334	603631	677942	731817	731817
Early Bon Chretien	384279	405584	430696	483562	521890	521890	521890	521890	521890	521890	521890	521890
Abate Fetel	153570	180672	212088	278226	326177	326177	326177	326177	326177	326177	326177	326177
Rosemarie	359927	359927	359927	359927	359927	359927	359927	359927	359927	359927	-125196	170445
Other	333505	359927	359927	359927	359927	359927	117365	265186	279750	297061	333505	359927
Total farm gross margin	**6156131**	**7229093**	**7888904**	**8478372**	**8735064**	**7549184**	**8025951**	**7968189**	**8344019**	**8092952**	**6734048**	**7458738**
Fixed Costs												
Labour	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408
Water rights	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996
Bank Costs	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Electricity	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000
Auditers fee	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
Communication	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000
Maintenance fixed improvements	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000
Fuel	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000
Maintenance & repairs	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265
Other												
Total fixed costs (b)	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**
Factor costs												
Hired management	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000
Rented land												
Payments	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90
Total factor costs ©	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**
Capital items												
Land	**27140000**				0,86570							

13	14	15	16	17	18	19	20	21	22	23	24	25
641337	281869	573657	603939	641337	720070	777151	338951	573657	603939	641337	281869	573657
409621	759397	848680	952918	409621	759397	848680	952918	1031097	1031097	1031097	409621	759397
370830	416326	450449	192356	332266	370830	416326	450449	192356	332266	370830	416326	450449
741699	832560	900705	420938	688496	741699	832560	900705	420938	688496	741699	832560	900705
741699	832560	900705	420938	688496	741699	832560	900705	420938	688496	741699	832560	900705
186470	186470	186470	186470	-547728	-21064	51200	128497	186470	186470	186470	186470	186470
290720	-128504	134828	186598	246096	290720	290720	290720	290720	290720	290720	-128504	134828
40204	65167	86608	102689	102689	102689	102689	-239617	40204	65167	86608	102689	102689
1405884	291515	1030618	1091623	1159475	187951	1030618	-22746	784209	988060	1159475	187951	1030618
389457	63223	284954	302286	321107	360730	389457	63223	284954	302286	321107	34497	284954
731817	731817	731817	731817	731817	167414	536965	3931	408780	514459	603631	113538	536965
162548	384279	46242	293085	367256	430696	124220	384279	405584	430696	483562	521890	162548
326177	326177	326177	326177	326177	326177	326177	-142071	153570	180672	212088	278226	-142071
199572	234194	307083	359927	359927	-125196	170445	199572	234194	307083	359927	359927	359927
359927	359927	359927	359927	359927	359927	359927	-125196	170445	-42989	139454	226906	297061
6997962	**5636978**	**7168920**	**6531686**	**6186959**	**5413738**	**7089694**	**4084320**	**5598117**	**6566919**	**7369704**	**4656526**	**6538902**
1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408	1585408
429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996	429996
24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000	276000
144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000	72000
780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000	780000
408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000	408000
379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265	379265
4098669	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**	**4098669**
288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000	288000
641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90	641214,90
929215	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**	**929215**

0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	127409,4	0	0	0	0	0	0	0	0	0	0
0	0	127409,4	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	293955,3	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	259396,2	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	299880	0	0	0
0	0	0	0	0	0	0	0	0	299880	0	0	0
0	0	0	0	0	0	0	0	0	0	0	93600	0
0	**293 955**	**254 819**	**0**	**0**	**0**	**259 396**	**0**	**0**	**599 760**	**0**	**93 600**	**0**
0	0	0	0	67788,9	0	0	0	0	0	0	0	0
0	0	53275,5	0	0	0	0	0	0	0	0	0	0
0	0	0	53275,5	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	33028,2	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	64483,2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	10800	0
0	34268,4	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	27000	0	0	0	0	0	0	0	0	0	0	0
20700	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	36000	0	0	0	0	0	0	0
20 700	**61 268**	**53 276**	**117 759**	**67 789**	**36 000**	**0**	**33 028**	**0**	**0**	**0**	**10 800**	**0**
20 700	**355 224**	**308 094**	**117 759**	**67 789**	**36 000**	**259 396**	**33 028**	**0**	**599 760**	**0**	**104 400**	**0**
20 700	**355 224**	**308 094**	**117 759**	**67 789**	**36 000**	**259 396**	**33 028**	**-**	**599 760**	**-**	**104 400**	**-**
1 949 378	**253 870**	**1 832 942**	**1 386 044**	**1 091 287**	**349 854**	**1 802 414**	**-976 592**	**570 233**	**939 275**	**2 341 821**	**-475 758**	**32 861 258**

Moveable assets													
Vehicles and machinery													
Two-wheeler		29 844	0	0	0	0	0	0	0	0	0	41967,9	0
Pickup truck													
LAA 2.5 Diesel Double Cab		52 379	0	0	0	127409,4	0	0	0	0	0	0	0
LAA 2.5 Diesel Double Cab		52 379	0	0	0	127409,4	0	0	0	0	0	0	0
Truck													
8t		150 797	0	0	0	0	0	0	0	0	295037,1	0	0
14t double axle		105 139	0	0	0	0	0	291154,5	0	0	0	0	0
Other operating vehicles													
Tractors													
Orchard		209 035	0	0	0	0	0	0	0	0	0	0	0
Orchard		130 150	0	0	0	0	0	0	0	0	0	231949,8	0
Orchard		169 949	0	0	0	0	0	0	0	0	0	151439,4	0
Orchard		249 309	0	0	0	0	0	0	0	0	0	0	0
Orchard		333 200	0	0	0	0	0	0	0	0	0	0	0
Orchard		333 200	0	0	0	0	0	0	0	0	0	0	0
0													
Forklift													
Forklift 3t		54 080	0	0	0	0	0	0	0	93600	0	0	0
Forklift 3t		117 800											
Total Vehicles and Machinery		**1 987 260**	**0**	**0**	**0**	**254 819**	**0**	**291 155**	**0**	**93 600**	**295 037**	**425 357**	**0**
Implements:													
Sprayer													
Towing sprayer (1) 1500l		24 479	0	0	0	67788,9	0	0	0	0	0	0	0
Towing sprayer (2) 1500l		19 238	0	53275,5	0	0	0	0	0	0	0	0	0
Turbmatic 1500l		14 799	0	0	53275,5	0	0	0	0	0	0	0	0
Three-point 400l (herbicides)		10 275	0	0	0	33028,2	0	0	0	0	0	0	0
Land preparation implements													
Plow		320	0	0	1800	0	0	0	0	0	0	0	0
Disc Plough 4 furrouw		9 800	0	0	0	0	31500	0	0	0	0	0	0
Ghrop		11 000	0	0	0	0	0	0	0	0	0	0	18000
Ander													
Tip trailer 3t		52 303	0	0	0	0	0	0	0	0	0	0	0
Trailer with Brake 3t		13 797	0	0	0	0	0	0	0	0	26994,6	0	0
Bin wagons		9 120	0	0	0	0	0	0	0	0	0	0	0
Rovic Chalk distributer		24 369	0	0	0	0	0	0	0	0	0	0	0
Bossieslaner 0,9m 3lem, ligte diens		6 127	0	0	0	0	0	0	0	0	0	0	10026
Electrical mobile waterpump		19 200	0	0	0	0	0	0	0	0	0	0	0
Content of workshop and equipment		13 685	0	0	0	0	0	0	0	0	0	0	0
Orchard equipment (pruning scissors, ladders, bags)		32 800	0	0	0	0	0	0	0	0	0	0	0
Total Implements		**261 313**	**0**	**53 276**	**55 076**	**100 817**	**31 500**	**0**	**0**	**0**	**26 995**	**0**	**28 026**
Total moveable		**2 248 573**	**0**	**53 276**	**55 076**	**355 636**	**31 500**	**291 155**	**0**	**93 600**	**322 032**	**425 357**	**28 026**
Total Capital (d)		**31 350 240**	**-**	**53 276**	**55 076**	**355 637**	**31 500**	**291 155**	**-**	**93 600**	**322 032**	**425 357**	**28 026**
Netto jaarlikse vloei (a-b-c-d)		**-30 221 993**	**2 201 209**	**2 807 744**	**3 395 413**	**3 351 543**	**2 489 800**	**2 706 913**	**2 940 305**	**3 222 535**	**2 743 036**	**1 280 807**	**2 402 828**
IRR		7,13%											
NPV	2,40%	21 211 421,71											

Annexure D: Enterprise budget for Panorama Golden

Panorama Golden										
Year	1	2	3	4	5	6	7	8	9	10
Income										
Expected yield (%)	0%	0%	12%	31%	71%	**100%**	**100%**	**100%**	**100%**	**100%**
Gross production value	**0**	**0**	**43425**	**112181**	**256931**	**361875**	**361875**	**361875**	**361875**	**361875**
Directly allocatable costs										
Establishment Costs	**306500**	**8459,84**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Land preperation	74208	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Drainage	19623	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Trelissing systems	53620	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Plant material	105748	8460	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Irrigation systems	34980	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Chemicals	6400	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Other	11921	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Pre-harvest Costs	**3230**	**3230**	**12307**	**26680**	**56937**	**78874**	**78874**	**78874**	**78874**	**78874**
Fertilizer	0	0	993	2566	5878	8279	8279	8279	8279	8279
Irrigation	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150
Pollination	0	0	241	622	1424	2005	2005	2005	2005	2005
Pesticides	0	0	1328	3430	7857	11066	11066	11066	11066	11066
Fungicides	0	0	392	1014	2322	3270	3270	3270	3270	3270
Herbicides	0	0	330	853	1953	2750	2750	2750	2750	2750
Labour	0	0	3503	9050	20727	29193	29193	29193	29193	29193
Rest-breaking chemicals	0	0	78	200	459	646	646	646	646	646
Fuel	0	0	972	2510	5748	8096	8096	8096	8096	8096
Maintenance and Repairs	0	0	1241	3205	7341	10339	10339	10339	10339	10339
Consultation	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080
Harvest costs	**0**	**0**	**2401**	**6202**	**14205**	**20007**	**20007**	**20007**	**20007**	**20007**
Labour	0,00	0,00	2400,84	6202,17	14204,97	20007,00	20007,00	20007,00	20007,00	20007,00

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
361875	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**	**361875**
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
78874	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**	**78874**
8279	8279	8279	8279	8279	8279	8279	8279	8279	8279	8279	8279	8279	8279	8279
2150	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150
2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
11066	11066	11066	11066	11066	11066	11066	11066	11066	11066	11066	11066	11066	11066	11066
3270	3270	3270	3270	3270	3270	3270	3270	3270	3270	3270	3270	3270	3270	3270
2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
29193	29193	29193	29193	29193	29193	29193	29193	29193	29193	29193	29193	29193	29193	29193
646	646	646	646	646	646	646	646	646	646	646	646	646	646	646
8096	8096	8096	8096	8096	8096	8096	8096	8096	8096	8096	8096	8096	8096	8096
10339	10339	10339	10339	10339	10339	10339	10339	10339	10339	10339	10339	10339	10339	10339
1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080
20007	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**	**20007**
20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00	20007,00

Other directly allocatable costs			**15487**	**584**	**615**	**1334**	**2847**	**3944**	**3944**	**3944**	**3944**	**3944**
Diverse and unforseeable costs			15487	584	615	1334	2847	3944	3944	3944	3944	3944
Total			**325217**	**12274**	**15323**	**34216**	**73989**	**102825**	**102825**	**102825**	**102825**	**102825**
Year			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gross production value			0	0	43425	112181	256931	361875	361875	361875	361875	361875
Directly allocatable costs			325217	12274	15323	34216	73989	102825	102825	102825	102825	102825
Gross margin			**325217**	**12274**	**28102**	**77965**	**182942**	**259050**	**259050**	**259050**	**259050**	**259050**
Block size	**3,00**	**age**										
Block	0,8	2	3	4	5	6	7	8	9	10	11	12
Block	0,8	6	7	8	9	10	11	12	13	14	15	16
Block	0,8	12	13	14	15	16	17	18	19	20	21	22
Block	0,8	16	17	18	19	20	21	22	23	24	25	1
		age										
Block	1	1	21076	58474	137207	194288	194288	194288	194288	194288	194288	194288
Block	2	2	194288	194288	194288	194288	194288	194288	194288	194288	194288	194288
Block	3	3	194288	194288	194288	194288	194288	194288	194288	194288	194288	194288
Block	4	4	194288	194288	194288	194288	194288	194288	194288	194288	194288	243912
Gross margin	**Panorama Golden**		**603939**	**641337**	**720070**	**777151**	**777150,59**	**777151**	**777151**	**777151**	**777151**	**338951**

3944	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**	**3944**
3944	3944	3944	3944	3944	3944	3944	3944	3944	3944	3944	3944	3944	3944	3944
102825	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**	**102825**
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
361875	361875	361875	361875	361875	361875	361875	361875	361875	361875	361875	361875	361875	361875	361875
102825	102825	102825	102825	102825	102825	102825	102825	102825	102825	102825	102825	102825	102825	102825
259050	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**	**259050**
13	14	15	16	17	18	19	20	21	22	23	24	25	1	2
17	18	19	20	21	22	23	24	25	1	2	3	4	5	6
23	24	25	1	2	3	4	5	6	7	8	9	10	11	12
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
194288	194288	194288	194288	194288	194288	194288	194288	194288	194288	194288	194288	194288	243912	9206
194288	194288	194288	194288	194288	194288	194288	194288	194288	243912	9206	21076	58474	137207	194288
194288	194288	194288	243912	9206	21076	58474	137207	194288	194288	194288	194288	194288	194288	194288
9206	21076	58474	137207	194288	194288	194288	194288	194288	194288	194288	194288	194288	194288	194288
573657	**603939**	**641337**	**281869**	**573657**	**603939**	**641337**	**720070**	**777151**	**338951**	**573657**	**603939**	**641337**	**281869**	**573657**

Annexure E: Production costs for apples

Input costs/ha	Apples
Establishment costs	
Land preperation	74208
Drainage	19623
Trelissing systems	53620
Plant material	105748
Irrigation systems	34980
Chemicals	6400
Pre-Harvest	
Fertilizer	8279
Irrigation	2150
Pollination	2005
Pesticides	11066
Fungicides	3270
Herbicides	2750
Labour	29193
Rest-breaking chemicals	5098
Fuel	8096
Maintenance and Repairs	10339
Consultation	1080
Harvest	
Labour	2007

Annexure F: Hortgro pome and stone fruit budget

POME FRUIT CROP BUDGETS

	APPLES			PEARS		
	ESTABLISH-MENT	NON-BEARING	BEARING	ESTABLISH-MENT	NON-BEARING	BEARING
	RAND	RAND	RAND	RAND	RAND	RAND
Yield (ton/ha)			**65**			**55**
Number of trees per ha	1 667	1 667	1 667	1 667	1 667	1 667
Pre-harvest costs	**317 829**	**25 139**	**86 472**	**298 573**	**23 534**	**83 778**
Plant material	105 748	2 115	0	86 434	1 729	0
Land clearing & soil mapping	23 780	0	0	23 780	0	0
Land preparation & ridging	48 600	0	0	48 600	0	0
Irrigation (design & material)	34 980	0	0	34 980	0	0
Drainage	19 623	0	0	19 623	0	0
Trellising	53 620	0	0	53 620	0	0
Fertilizer	8 751	7 373	8 279	8 680	7 271	14 104
Herbicides	2 750	2 750	2 750	2 750	2 750	2 750
Pesticides	466	850	11 066	577	825	14 321
Fungicides	731	1 090	3 270	501	716	3 740
Rest breaking agents/ Growth Regulators	0	1 129	5 098	0	1 129	3 001
Consultants	1 080	1 080	1 080	1 080	1 080	1 080
Seasonal Labour	10 331	0	29 193	10 349	0	23 633
Fuel (diesel)	1 828	2 269	8 096	1 929	2 648	5 201
Repairs and maintenance	2 335	2 898	10 339	2 464	1 803	6 642
Electricity	1 661	3 321	5 033	1 661	3 321	5 033
General	1 545	262	262	1 545	262	262
Pollination	0	0	2 005	0	0	4 010
Harvest & Post-Harvest	**0**	**0**	**250 890**	**0**	**0**	**207 143**
Transport rental	0	0	28 536	0	0	22 790
Packaging	0	0	200 828	0	0	166 320
Seasonal Labour	0	0	20 007	0	0	16 929
Fuel (diesel)	0	0	1 129	0	0	821
Repairs and maintenance	0	0	390	0	0	284
Overhead costs	**79 638**	**64 638**	**80 639**	**77 688**	**63 593**	**77 296**
Fixed labour	18 006	18 006	18 006	18 006	18 006	18 006
Water costs	2 150	2 150	2 150	2 150	2 150	2 150
Other overheads	27 302	27 302	27 302	27 302	27 302	27 302
Interest on loans	16 289	1 288	17 290	15 302	1 206	14 910
Depreciation on orchard	15 891	15 891	15 891	14 929	14 929	14 929
Total cost	**397 467**	**89 777**	**418 001**	**376 262**	**87 126**	**368 217**

* These budgets are only a guideline and should be adapted to your own specific situation
* Other overheads = admin, bank charges, general repairs, local taxes, postage, phone, auditing, secretarial, etc.
* If re-establishing an orchard an amount of between R5/meter to R13/meter should be added for soil fumigation

STONE FRUIT CROP BUDGETS

	APRICOTS			NECTARINES/PEACHES			PLUMS		
	ESTABLISH-MENT	NON-BEARING	BEARING	ESTABLISH-MENT	NON-BEARING	BEARING	ESTABLISH-MENT	NON-BEARING	BEARING
	RAND	RAND	RAND	RAND	RAND	RAND	RAND	RAND	RAND
Yield (ton/ha)			**20**			**25**			**30**
Number of trees per ha	1 250	1 250	1 250	1 250	1 250	1 250	1 524	1 524	1 524
Pre-harvest costs	**195 517**	**20 246**	**72 417**	**201 482**	**20 383**	**80 249**	**277 098**	**25 592**	**89 113**
Plant material	50 254	1 005	0	56 711	1 134	0	67 310	1 346	0
Land clearing & soil mapping	23 780			23 780			23 780		
Land prepara-tion & ridging	48 600	0	0	48 600	0	0	48 600	0	0
Irrigation (design & material)	34 980	0	0	34 980	0	0	34 980	0	0
Drainage	19 623	0	0	19 623	0	0	19 623	0	0
Trellising	0	0	0	0	0	0	64 380	0	0
Fertilizer	8 785	4 100	8 872	7 362	4 100	11 771	7 825	4 893	15 867
Herbicides	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750	2 750
Pesticides	149	750	4 570	477	682	9 035	1 132	1 185	5 768
Fungicides	540	540	9 922	193	276	13 742	155	207	3 275
Rest breaking agents/Growth Regulators	0	995	1 836	0	0	0	0	0	5 249
Consultants	1 080	1 080	1 080	1 080	1 080	1 080	1 080	1 080	1 080
Seasonal Labour	0	3 270	22 504	0	3 409	22 594	0	7 295	26 598
Fuel (diesel)	1 147	1 513	8 110	1 261	1 639	8 109	971	1 387	7 854
Repairs and maintenance	858	1 132	10 907	1 696	2 204	10 906	1 306	1 865	10 563
Electricity	1 423	2 847	0	1 423	2 847	0	1 661	3 321	5 033
General	1 545	262	262	1 545	262	262	1 545	262	262
Pollination	0	0	1 604	0	0	0	0	0	4 812
Harvest & Post-Harvest	**0**	**0**	**80 535**	**0**	**0**	**142 683**	**0**	**0**	**189 526**
Transport rental	0	0	13 234	0	0	23 519	0	0	28 930
Packaging	0	0	54 442	0	0	108 911	0	0	149 069
Seasonal Labour	0	0	12 368	0	0	9 640	0	0	10 760
Fuel (diesel)	0	0	365	0	0	456	0	0	570
Repairs and maintenance	0	0	126	0	0	158	0	0	197
Overhead costs	**67 254**	**58 271**	**65 073**	**67 858**	**58 577**	**68 957**	**75 514**	**62 624**	**75 593**
Fixed labour	18 006	18 006	18 006	18 006	18 006	18 006	18 006	18 006	18 006
Water costs	2 150	2 150	2 150	2 150	2 150	2 150	2 150	2 150	2 150
Other overheads	27 302	27 302	27 302	27 302	27 302	27 302	27 302	27 302	27 302
Interest on loans	10 020	1 038	7 839	10 326	1 045	11 425	14 201	1 312	14 280
Depreciation on orchard	9 776	9 776	9 776	10 074	10 074	10 074	13 855	13 855	13 855
Total cost	**262 771**	**78 517**	**218 024**	**269 340**	**78 960**	**291 889**	**352 612**	**88 216**	**354 232**

* These budgets are only a guideline and should be adapted to your own specific situation
* Other overheaads = admin, bank charges, general repairs, local taxes, postage, phone, auditing, secretarial, etc.
* If re-establishing an orchard an amount of R13/meter should be added for soil fumigation